Yuba County Water Agency

NARROWS 2 POWERPLANT

FLOW BYPASS SYSTEM
FINAL DESIGN REPORT

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NARROWS 2 POWERPLANT
FLOW BYPASS SYSTEM PROJECT

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1. INTRODUCTION

1.1 Purpose

This design report presents the final design of the Narrows 2 Powerplant Flow Bypass System Project.

1.2 Abbreviations

For convenience the following abbreviations are adopted to refer to the various valves of the flow bypass system:

BPV1 Existing 36-in. bypass valve on turbine scrollcase

BPV2 Proposed flow bypass valve

TSV Proposed turbine shutoff valve

1.3 Existing Facilities

1.3.1. PHYSICAL DESCRIPTION

The Narrows 2 Hydro Powerplant is part of the Yuba River Development (FERC No. 2246), owned and operated by the Yuba County Water Agency. The 55 MW powerhouse is located on the Yuba River about 400 feet downstream of Englebright Dam.

Water to the turbine is delivered from the intake structure located in Englebright Reservoir about 200 ft. upstream of the dam, through a 717-foot long power tunnel. The upstream 349 ft. of the tunnel is a concrete lined 9’-2” radius horseshoe and the downstream 368 ft. to the powerhouse is a 14-ft. diameter circular steel lined tunnel.

At full load and full head (235.0 ft. gross head), Narrows 2 has a discharge capacity of about 3,400 cfs. There is no turbine shut-off valve and a fixed wheel gate in the intake structure controls the discharge to the powerhouse. A 36-inch bypass valve (BPV1) is provided on the scroll case to maintain the required downstream flow in case no other supply is available. This bypass has a nominal release capacity of about 650 cfs.

Narrows 1 powerhouse (FERC No. 1403), owned and operated by PG&E is located on the opposite side of the river about 500 ft. downstream of Narrows 2. It is a 12.0 MW powerhouse with a maximum gross head of 240 ft. and a discharge capacity of 730 cfs at normal maximum gross head.

1.3.2. CURRENT OPERATING MODES

1. Narrows 2 Unit Generating

All flows, up to a maximum of 3,400 cfs are discharged through the turbine. During normal turbine operation, the bypass valve on the scroll case is closed and the intake gate is fully open.

2. Instream Flow and Ramping Requirements

The California State Water Resources Control Board (SWRCB) has established instream flow and release requirements. Currently, the project is operating under the interim requirements. After April 21, 2006, more stringent requirements will apply. Appendix A an extract of the SWRCB “Order for Interim and Long Term Flow Requirements”, provides details of minimum flow and ramping rate requirements.

3. Ramping Operation

When generator load is reduced by the automatic load dispatch system, (when ramping down) the bypass valve is manually opened to meet ramping requirements. Similarly, when ramping up, the bypass valve is gradually closed manually or from local controls.

4. Full Unit Shutdown

When there is a sudden shutdown of the unit because of a forced outage, the wicket gates close. In the case of a line failure, the power intake gate is automatically lowered to prevent the unit attaining a runaway condition, resulting in emptying of the tunnel and scrollcase. The downstream releases are then reduced to releases from Narrows 1 (if it is operating). The duration of such flow reduction depends upon the day and time when the tripping occurred, because most of the time the powerplant is unattended. Restarting is a manual operation that typically takes several hours. To restart the unit, the turbine wicket gates and the scrollcase bypass valve are closed and the tunnel and scroll case are filled either by partially raising the intake gate or through the filling line. Then the gate is fully opened and the unit restarted.

5. Operational Constraints

When there is a sudden shutdown due to a line failure, the intake gate closes resulting in no flow through the bypass. When the Agency is generating at high rates and Narrows 2 gets tripped off line, the ramping rate in the river downstream of the powerhouse at times exceeds the rate of 500 cfs per hour.

Since Steelhead Trout and spring run Chinook Salmon have been listed as a threatened species, exceedence of the ramping rate criteria can become a critical issue.

1.4 Proposed Flow Bypass System

1.4.1. OBJECTIVES

The principal objectives of the proposed flow bypass system are to address the following issues:

- Make uninterrupted releases from Narrows 2, at the same flow rate as was being discharged before an event occurs that reduces flow.
- During up and down ramping operation of the powerplant unit, the

rate of change in river flow or releases from Narrows 2, will comply with the SWRCB Order (See Appendix A) and the FERC license conditions.

1.4.2. GENERAL DESCRIPTION OF CONCEPT

The proposed modifications include installation of a turbine shutoff valve and a new flow bypass system. The turbine shutoff valve (TSV) and the new flow bypass valve (BPV2) will be synchronized to maintain constant flow (up to a maximum of 3000 cfs) to the river as the shutoff valve or turbine wicket gates close or open. The TSV will close for all conditions that previously caused the intake gate to close and BPV2 will open to permit a smooth transfer of the flow.

Figure 1-1 shows a general arrangement plan of the system.

1. Turbine Shutoff Valve

The TSV will be a 14-foot diameter butterfly valve, complete with its servomotor and automatic remote controls and all other auxiliaries, and will be installed in the powerhouse between the 14-foot diameter 7/8 inch thick steel liner (penstock) and the scroll case. Installation of the valve will require removal of sufficient length of the existing steel liner, welding flanges on the ends of the liner to accommodate the valve and reinstallation of the coupling downstream of valve.

Powerhouse structural modifications will be necessary to create the required space and clearances for valve installation.

Figure 1-2 shows the general arrangement of the TSV installation.

2. Flow Bypass System

The flow bypass system will consist of the following components:

- A bypass conduit, consisting of a steel lined tunnel, tapping into the power tunnel at a new wye branch (bifurcation) about 50 ft. upstream of the TSV.
- A new reinforced concrete valve structure
- A 78 in. diameter fixed cone valve (BPV2) located in the valve structure.
- A 78 in. diameter guard valve (bonneted knife gate valve or bonneted slide gate) upstream of BPV2.
- An acoustic flow meter.
- The existing 36 in. diameter bypass valve (BPV1) located on the turbine scrollcase.

Figure 1-3 and Figure 1-4 show the flow bypass system equipment arrangement in the bypass valve structure.

3. Elevations Dimensions and Miscellaneous Data

Englebright Lake:

Normal Max. Res. W. S.	El. 527.0
Min Res. W. S.	El. 475.0
Normal Tailwater:	El. 290.0
Centerline of distributor and penstock:	El. 292.0
Powerhouse Top Deck:	El. 348.0
Tunnel Steel Liner (Penstock) diameter (I. D.):	14 ft.
Liner Steel Thickness:	7/8 in.
Runner removal hatches in powerhouse:	14 ft. x 14 ft.
Existing Steel Liner:	ASTM A-285, firebox, Grade B

1.5 Final Design

During the final design process a number of changes to the feasibility design were made to improve hydraulic and operational performance and reduce costs. The major changes are summarized as follows:

1.5.1. Bypass/Penstock Junction

Concerns regarding the 90-degree bend at the junction of the penstock and bypass line buy the Agency and the Project Review Panel. The feasibility design had adopted the 90-degree bend (Tee junction) because it was believed that it would be the easiest way from the constructibility standpoint to tap into the steel lined tunnel. The unfavorable hydraulics inherent in the 90-degree bend were deemed to be acceptable because of the expected infrequent operation of the bypass. The Agency, Review Panel and CAI now believe that the bypass will probably operate more frequently that originally expected and since future changes in operating criteria cannot be predicted, the unfavorable hydraulics of the tee junction were deemed unacceptable.

The revised design consists of a wye branch (bifurcation) installed in a large diameter shaft excavated from the ground surface above the centerline of the penstock. A section of penstock will be removed and the prefabricated wye branch will be installed. The bypass branch will be at 45 degrees from the penstock and the bypass valve structure will be relocated along a projection of the centerline of this branch. The requirement for a straight section of conduit for 10 diameters (65 ft.) upstream of the fixed cone valve (BPV2) determines the location of the bypass structure.

Since the terrain above the power tunnel rises abruptly upstream of the yard behind the powerhouse, the shaft will be located as close to the powerhouse as practical to minimize the required excavation.

1.5.2. ACOUSTIC FLOW METER

Two acoustic flow meters were originally proposed; one to measure bypass flow located in a chamber of the bypass valve structure and one located upstream of the TSV to measure turbine flow. During discussions with the Agency staff, it was decided that two meters would be unnecessary because simultaneous operation of the turbine and the bypass would be only for short intervals during the transition for full turbine flow to full bypass flow.

A single acoustic flow meter (with backup probe) will be installed in the penstock about 50 feet upstream of the wye branch. It will provide a measurement of discharge into the river either through the turbine or the bypass valve. This revision provides a significant cost savings because the chamber in the bypass valve structure is unnecessary.

1.5.3. BYPASS VALVE ELEVATION

The bypass valve centerline was originally located at El. 292.0, the same elevation as the penstock centerline. Based on the normal tailwater level of El. 287 shown on the Narrows Project drawings, the valve centerline would be 5 ft. above normal tailwater. Recent tailwater measurements indicate that normal tailwater is 3 to 4 feet higher than the value shown on the drawings, which would cause the bottom part of the valve to be submerged below tailwater level. While the valve could probably function properly without restriction with this minimal submergence, it is undesirable for the equipment to be partially submerged most of the time in this manner. The elevation of the valve was therefore raised by 5 feet. The bypass tunnel will slope upward at about 6% along a straight line from the wye branch at centerline elevation El. 292.0 to the valve at El. 297.0. This revision provides a significant cost savings because of the reduced amount of structural excavation required and the reduced volume of concrete resulting from the 5-foot shorter structure.

1.6 Scope of Work

The scope of work for final design as described more fully in Exhibit A of the Consulting Services Agreement between the Yuba County Water Agency (Agency) and Christensen Associates Inc. (CAI) consists of the following tasks:

Task A – Project Management
Task B – Meetings
Task 1 – Site Visit, Data Collection & Review
Task 2 – Preparation of Design Basis Memorandum
Task 3 – Topographic Mapping
Task 4 – Detailed Design

- Geology / Geotechnical
- Civil / Structural Design
- Mechanical Design
- Electrical Design

Task 5 – Drawings
Task 6 – Specifications
Task 7 – Constructibility Review
Task 8 – Construction Plan and Schedule
Task 9 – Engineer's Cost Estimate
Task 10 – Final Design Report
Task 11 – Submittal of Deliverables

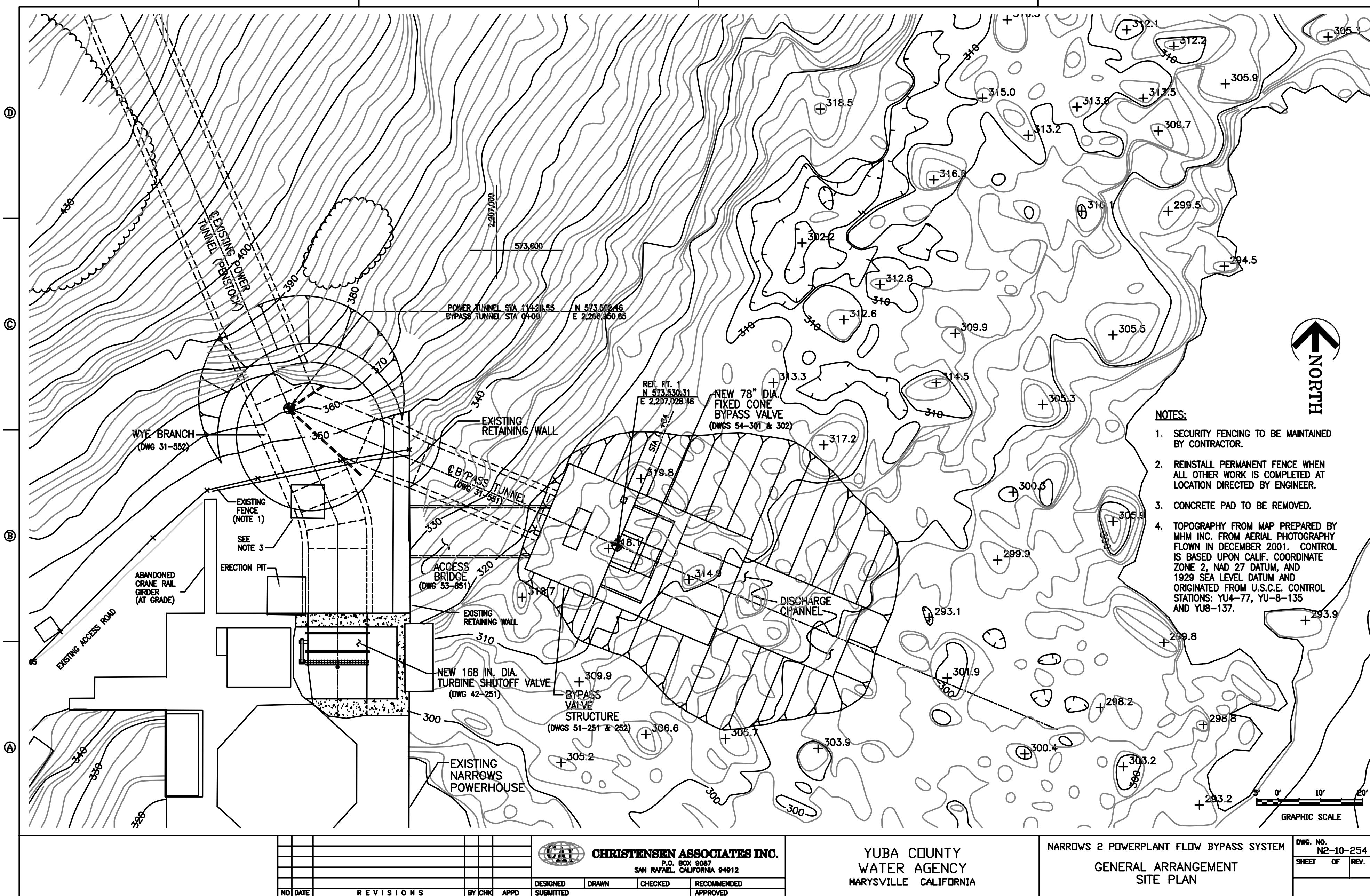
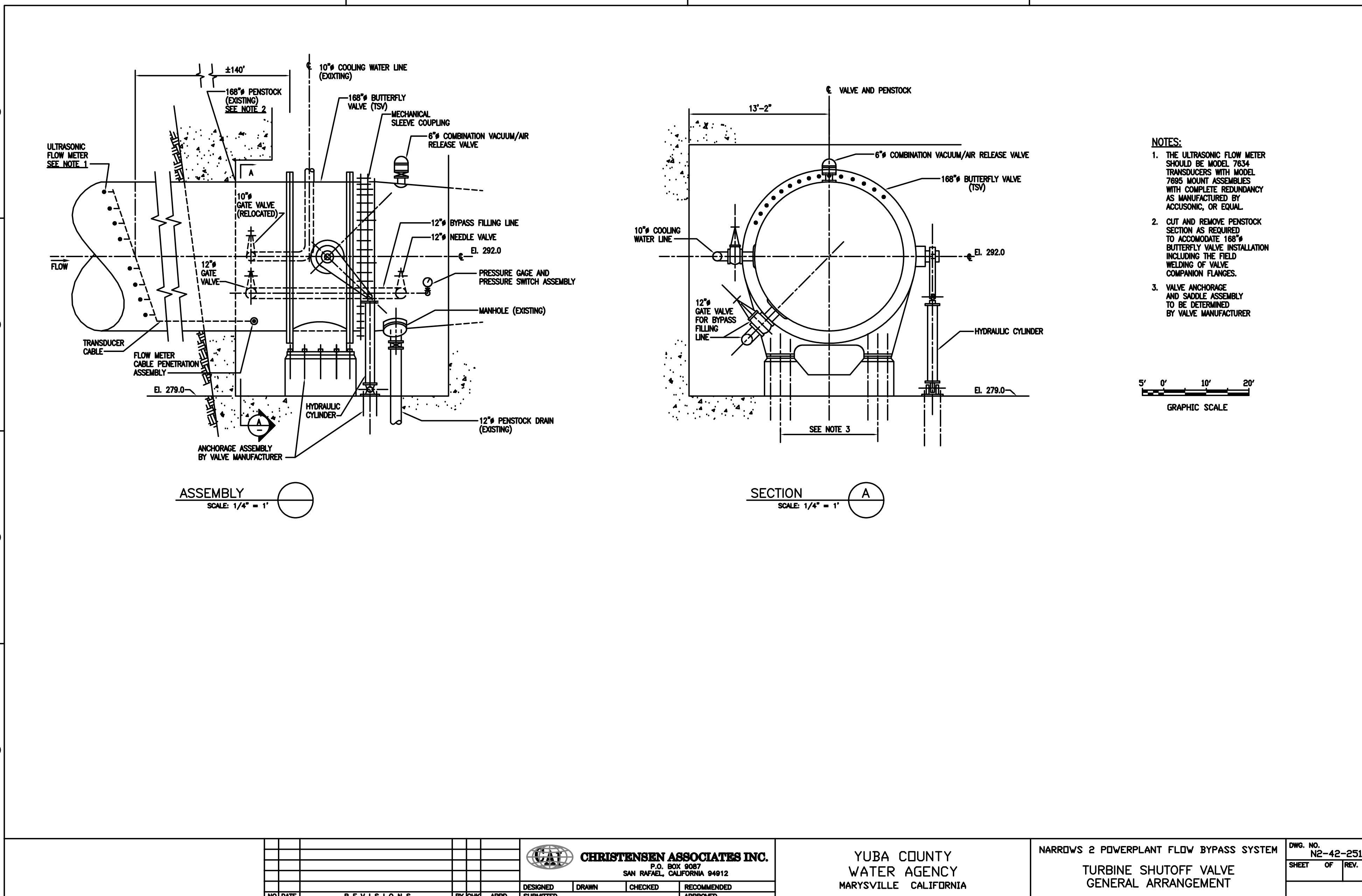

NORTH
NOTES:
1. SECURITY FENCING TO BE MAINTAINED BY CONTRACTOR.
2. REINSTALL PERMANENT FENCE WHEN ALL OTHER WORK IS COMPLETED AT LOCATION DIRECTED BY ENGINEER.
3. CONCRETE PAD TO BE REMOVED.
4. TOPOGRAPHY FROM MAP PREPARED BY MHM INC. FROM AERIAL PHOTOGRAPHY FLOWN IN DECEMBER 2001. CONTROL IS BASED UPON CALIF. COORDINATE ZONE 2, NAD 27 DATUM, AND 1929 SEA LEVEL DATUM AND ORIGINATED FROM U.S.C.E. CONTROL STATIONS: YU4-77, YU-8-135 AND YU8-137.
℄ EXISTING POWER TUNNEL (PENSTOCK)
WYE BRANCH (DWG 31-552)
EXISTING FENCE (NOTE 1)
SEE NOTE 3
ABANDONED CRANE RAIL GIRDER (AT GRADE)
ERECTION PIT
EXISTING ACCESS ROAD
POWER TUNNEL STA 11+28.55 BYPASS TUNNEL STA 0+00
N 573,582.46 E 2,206,950.85
573,600
2,207,000
EXISTING RETAINING WALL
℄ BYPASS TUNNEL (DWG 31-551)
ACCESS BRIDGE (DWG 53-851)
EXISTING RETAINING WALL
NEW 168 IN. DIA. TURBINE SHUTOFF VALVE (DWG 42-251)
EXISTING NARROWS POWERHOUSE
BYPASS VALVE STRUCTURE (DWGS 51-251 & 252)
REF. PT. 1 N 573,530.31 E 2,207,028.46
NEW 78" DIA. FIXED CONE BYPASS VALVE (DWGS 54-301 & 302)
DISCHARGE CHANNEL
GRAPHIC SCALE
5' 0' 10' 20'
CHRISTENSEN ASSOCIATES INC.
P.O. BOX 9087
SAN RAFAEL, CALIFORNIA 94912
DESIGNED DRAWN CHECKED RECOMMENDED
SUBMITTED APPROVED
NO DATE REVISIONS BY CHK APPD
YUBA COUNTY
WATER AGENCY
MARYSVILLE CALIFORNIA
NARROWS 2 POWERPLANT FLOW BYPASS SYSTEM
GENERAL ARRANGEMENT
SITE PLAN
DWG. NO. N2-10-254
SHEET OF REV.

FIGURE 1-1



ULTRASONIC FLOW METER SEE NOTE 1
±140'
168"ø PENSTOCK (EXISTING) SEE NOTE 2
10"ø COOLING WATER LINE (EXIXTING)
168"ø BUTTERFLY VALVE (TSV)
MECHANICAL SLEEVE COUPLING
6"ø COMBINATION VACUUM/AIR RELEASE VALVE
10"ø GATE VALVE (RELOCATED)
12"ø BYPASS FILLING LINE
12"ø NEEDLE VALVE
EL 292.0
FLOW
12"ø GATE VALVE
PRESSURE GAGE AND PRESSURE SWITCH ASSEMBLY
MANHOLE (EXISTING)
TRANSDUCER CABLE
FLOW METER CABLE PENETRATION ASSEMBLY
EL 279.0
HYDRAULIC CYLINDER
12"ø PENSTOCK DRAIN (EXISTING)
ANCHORAGE ASSEMBLY BY VALVE MANUFACTURER
ASSEMBLY
SCALE: 1/4" = 1'
VALVE AND PENSTOCK
13'-2"
6"ø COMBINATION VACUUM/AIR RELEASE VALVE
168"ø BUTTERFLY VALVE (TSV)
10"ø COOLING WATER LINE
12"ø GATE VALVE FOR BYPASS FILLING LINE
HYDRAULIC CYLINDER
SEE NOTE 3
SECTION
SCALE: 1/4" = 1'
NOTES:
1. THE ULTRASONIC FLOW METER SHOULD BE MODEL 7634 TRANSDUCERS WITH MODEL 7695 MOUNT ASSEMBLIES WITH COMPLETE REDUNDANCY AS MANUFACTURED BY ACCUSONIC, OR EQUAL.
2. CUT AND REMOVE PENSTOCK SECTION AS REQUIRED TO ACCOMODATE 168"ø BUTTERFLY VALVE INSTALLATION INCLUDING THE FIELD WELDING OF VALVE COMPANION FLANGES.
3. VALVE ANCHORAGE AND SADDLE ASSEMBLY TO BE DETERMINED BY VALVE MANUFACTURER
5' 0' 10' 20'
GRAPHIC SCALE
NO DATE REVISIONS BY CHK APPD
CHRISTENSEN ASSOCIATES INC.
P.O. BOX 9087
SAN RAFAEL, CALIFORNIA 94912
DESIGNED DRAWN CHECKED RECOMMENDED
SUBMITTED APPROVED
YUBA COUNTY
WATER AGENCY
MARYSVILLE CALIFORNIA
NARROWS 2 POWERPLANT FLOW BYPASS SYSTEM
TURBINE SHUTOFF VALVE
GENERAL ARRANGEMENT
DWG. NO. N2-42-251
SHEET OF REV.

FIGURE 1-2

FIGURE 1-3

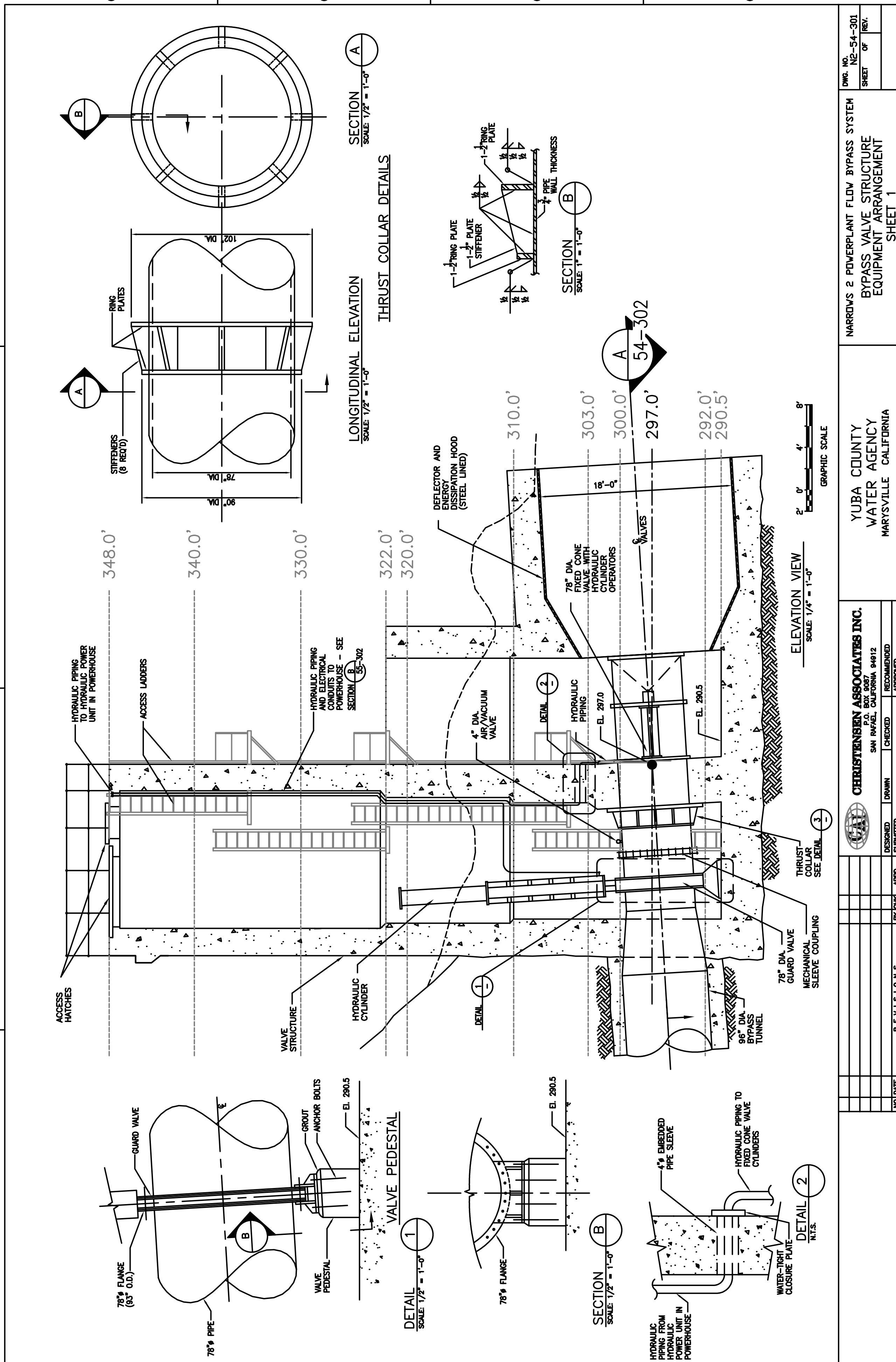
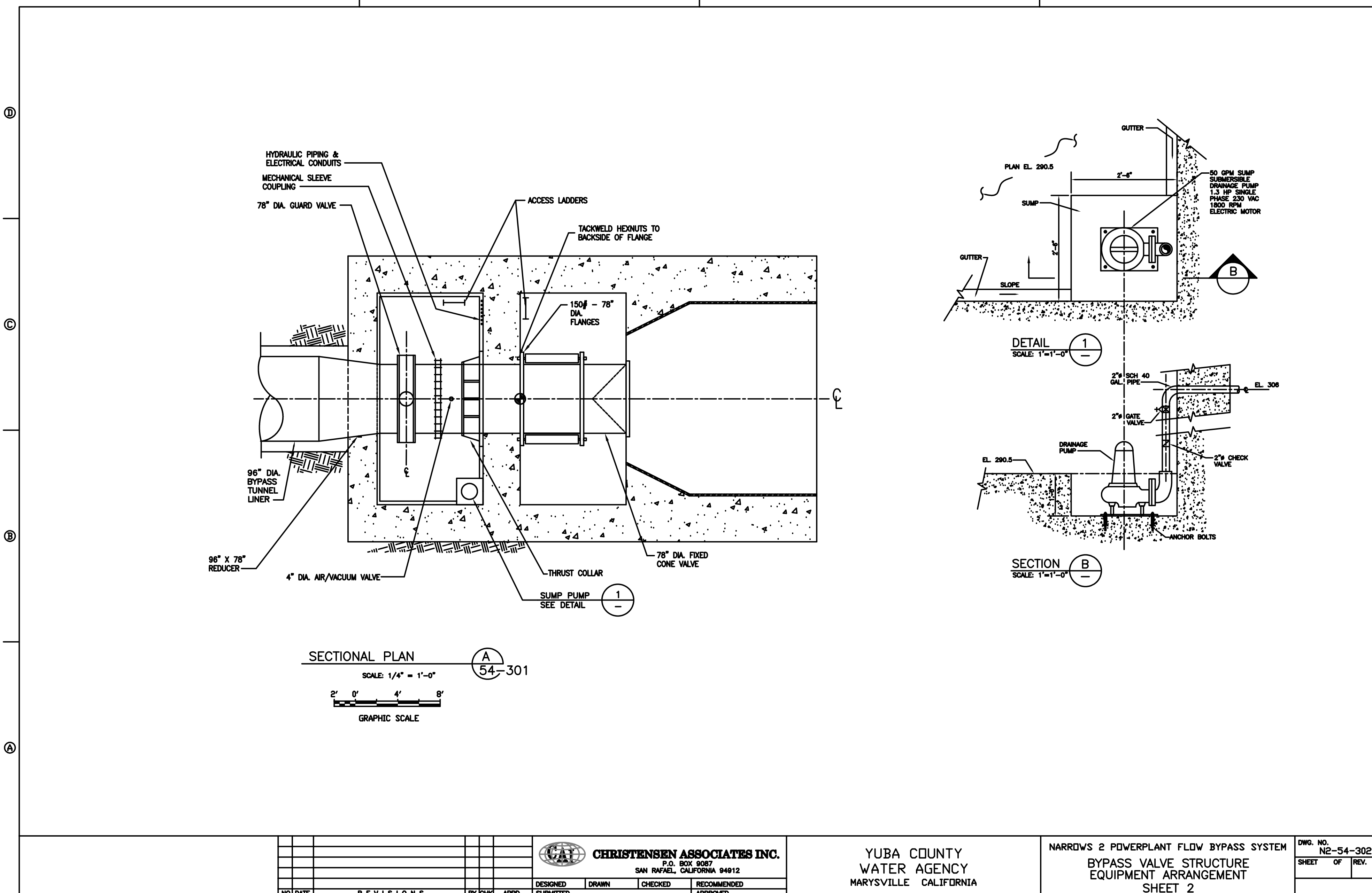

NARROWS 2 POWERPLANT FLOW BYPASS SYSTEM
BYPASS VALVE STRUCTURE
EQUIPMENT ARRANGEMENT
SHEET 1
DWG. NO. N2-54-301
YUBA COUNTY
WATER AGENCY
MARYSVILLE CALIFORNIA
CHRISTENSEN ASSOCIATES INC.
P.O. BOX 9087
SAN RAFAEL, CALIFORNIA 94912
DESIGNED
SUBMITTED
DRAWN
CHECKED
RECOMMENDED
APPROVED
REVISIONS
NO DATE
BY CHK APPD
ELEVATION VIEW
SCALE: 1/4" = 1'-0"
GRAPHIC SCALE
THRUST COLLAR DETAILS
LONGITUDINAL ELEVATION
SCALE: 1/2" = 1'-0"
SECTION A
SCALE: 1/2" = 1'-0"
SECTION B
SCALE: 1" = 1'-0"
102" DIA.
78" DIA.
90" DIA.
RING PLATES
STIFFENERS (8 REQ'D)
1-1/2" RING PLATE
1-1/2" PLATE STIFFENER
3/4" PIPE WALL THICKNESS
348.0'
340.0'
330.0'
322.0'
320.0'
310.0'
303.0'
300.0'
297.0'
292.0'
290.5'
A 54-302
HYDRAULIC PIPING TO HYDRAULIC POWER UNIT IN POWERHOUSE
ACCESS LADDERS
HYDRAULIC PIPING AND ELECTRICAL CONDUITS TO POWERHOUSE - SEE SECTION B 55-302
4" DIA. AIR/VACUUM VALVE
DETAIL 2
HYDRAULIC PIPING
EL. 297.0
EL. 290.5
DEFLECTOR AND ENERGY DISSIPATION HOOD (STEEL LINED)
18'-0"
78" DIA. FIXED CONE VALVE WITH HYDRAULIC CYLINDER OPERATORS
℄ VALVES
THRUST COLLAR SEE DETAIL 3
ACCESS HATCHES
VALVE STRUCTURE
HYDRAULIC CYLINDER
DETAIL 1
78" DIA. GUARD VALVE
MECHANICAL SLEEVE COUPLING
96" DIA. BYPASS TUNNEL
GUARD VALVE
GROUT
ANCHOR BOLTS
EL. 290.5
78"Φ FLANGE (93" O.D.)
78"Φ PIPE
VALVE PEDESTAL
DETAIL 1
SCALE: 1/2" = 1'-0"
78"Φ FLANGE
SECTION B
SCALE: 1/2" = 1'-0"
4"Φ EMBEDDED PIPE SLEEVE
HYDRAULIC PIPING TO FIXED CONE VALVE CYLINDERS
HYDRAULIC PIPING FROM HYDRAULIC POWER UNIT IN POWERHOUSE
WATER-TIGHT CLOSURE PLATE
DETAIL 2
N.T.S.

FIGURE 1-4


HYDRAULIC PIPING & ELECTRICAL CONDUITS
MECHANICAL SLEEVE COUPLING
78" DIA. GUARD VALVE
ACCESS LADDERS
TACKWELD HEXNUTS TO BACKSIDE OF FLANGE
150# - 78" DIA. FLANGES
96" DIA. BYPASS TUNNEL LINER
96" X 78" REDUCER
4" DIA. AIR/VACUUM VALVE
THRUST COLLAR
SUMP PUMP SEE DETAIL
78" DIA. FIXED CONE VALVE
SECTIONAL PLAN
SCALE: 1/4" = 1'-0"
54-301
2' 0' 4' 8'
GRAPHIC SCALE
GUTTER
PLAN EL. 290.5
2'-6"
SUMP
50 GPM SUMP SUBMERSIBLE DRAINAGE PUMP 1.3 HP SINGLE PHASE 230 VAC 1800 RPM ELECTRIC MOTOR
SLOPE
DETAIL
SCALE: 1'=1'-0"
2"ø SCH 40 GAL. PIPE
EL. 306
2"ø GATE VALVE
DRAINAGE PUMP
EL. 290.5
2"ø CHECK VALVE
ANCHOR BOLTS
SECTION
SCALE: 1'=1'-0"
NO DATE REVISIONS BY CHK APPD
CHRISTENSEN ASSOCIATES INC.
P.O. BOX 9087
SAN RAFAEL, CALIFORNIA 94912
DESIGNED DRAWN CHECKED RECOMMENDED
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YUBA COUNTY
WATER AGENCY
MARYSVILLE CALIFORNIA
NARROWS 2 POWERPLANT FLOW BYPASS SYSTEM
BYPASS VALVE STRUCTURE
EQUIPMENT ARRANGEMENT
SHEET 2
DWG. NO. N2-54-302
SHEET OF REV.

2. PROPOSED FLOW CONTROL SYSTEM

2.1 General

The proposed flow control system for the Narrows 2 powerplant is based on the use of a programmable logic controller (PLC), which will be able to perform the required calculations and logic control that are necessary for maintaining the required flows and ramping rates established for the project. A PC computer will be used in conjunction with the PLC to enable the operator to change the basic parameters and be able to assign new values to the flows, to change the ramping rates and to change the speeds at which the valves and wicket gates will operate.

2.2 Flow Metering Device

An acoustic flow meter (with a backup probe) will be installed in the penstock about 50 ft upstream of the wye branch. Flow data from the acoustic meter will be available at the flow indicating panel at the powerhouse turbine floor El. 304 and the Narrows 2 Control Room and will be entered into the PLC system in order to control and maintain the established flow regime. Flow meter data will also be available remotely at the Agency's Colgate Powerhouse and PG&E's Wise Switching Center. As a back up the bypass valve position transducer will convey valve position data and in conjunction with the prevailing reservoir head data, the PLC will compute the flow through the valve.

2.3 Flow Criteria

Two basic flow requirements, namely; minimum flow and ramping rate must be maintained in order to comply with the requirements of the California State Water Resources Control Board (SWRCB) as well as FERC license requirements.

The minimum required flows in the outlet channel vary during the season. Ramping rates (the rate of flow change) vary according to the total releases and other factors. Appendix A, which is extracted from the SWRCB Order for Interim and Long Term Flow Requirements, provides details of minimum flow and ramping rate requirements.

Based on the flow requirements, the following flow control procedure is proposed:

2.4 Proposed Flow Control Procedures

Base on a maximum ramping rate of 500 cfs per hour, it is proposed that ramping steps of 40 cfs every 5 minutes or a total of 480 cfs per hour be used. The following control sequences are considered;

2.4.1. CASE I

- Initial Condition

- Wicket gates closed (unit not running)
- TSV open
- Intake gate open
- BPV2 open and discharging minimum required flow.
- BPV1 in closed position[1]

- Function Required: To start unit and connect to grid with predetermined flow setting and the associated generating output.
- Proposed Control Sequence
  - Starting the unit can be initiated locally or remotely by energizing the unit "START" switch.
  - Unit will start by opening the wicket gates to "NO-LOAD" speed position.
  - The PLC will initiate the start of closing of BPV2 at the established ramping rate.
  - Unit is synchronized and connected to grid. PLC to start loading the unit at the established ramping rate until the desired (Predetermined) flow (and generating load) is obtained
  - BPV2 fully closed.

2.4.2. CASE II

- Initial Condition
  - Unit online and generating (assume flows up to 3000 cfs)
  - BPV2 in closed position
  - BPV1 in closed position
- Function Required: Unload the generating unit (Planned) and maintain flow release
- Proposed Control Sequence
  - Unloading (Manual – remote or local) will start by energizing the "STOP" relay.
  - Wicket gates closing
  - BPV2 is opening and delivering approximately the same flow that was passing through the generating unit
  - Turbine shutoff valve stays open.
  - BPV1 stays closed.

[1] It will be possible to operate BPV1 manually to synchronize load/flow changes between Narrows 1 and Narrows 2.

2.4.3. CASE III

- Initial Condition
  - Unit online and generating (assume flows up to 3000 cfs)
  - BPV2 in closed position
  - BPV1 in closed position
- Function Required: Emergency Shutdown, return stream flow
- Proposed Control Sequence
  - The wicket gates and turbine shutoff valve will close at the established closure rate.
  - At the same time BPV2 opens up to the required opening to restore the same flow that was passing through the generating unit.
  - BPV1 stays closed.
  - Intake gate stays open

2.4.4. CASE IV

- Initial Condition
  - Unit online and generating (assume flows at 3000 to 3400 cfs)
  - BPV2 in closed position
  - BPV1 in closed position
- Function Required: Unloading the generating unit (Planned) and in case of emergency shutdown
- Proposed Control Sequence
  - Same sequence as Case II and Case III above except that flows through BPV2 will be limited to 3000 cfs.

3. FINAL DESIGN –CIVIL FEATURES

3.1 Design Criteria

3.1.1. STRUCTURAL DESIGN

1. Design Loads

Dead weight of concrete – 150 lb/cf

Weight of valves and control equipment – as furnished by manufacturer.

Hydrostatic loading due to water pressure in tunnel and bypass conduit:

Normal Maximum Conditions:

Reservoir Water Surface	El. 527.0
C.L. Penstock	El. 292.0
Gross Head	235.0 ft. (102 psi)
Internal design pressure =	130 psi

(representing hydrostatic pressure including surge in the penstock due to sudden shutdown of the unit because of a forced outage.)

External hydrostatic loading on valve structure:

Normal Maximum Conditions:
Water Surface El. 290.0 (Normal tailwater)
Unusual Conditions (Flood)
Water Surface El. 348 (Top deck of valve structure)

Seismic Design –

The project site is located 3.7 miles (6.0 km) east of the Swain Ravine fault zone, which continues north to include the Cleveland Hill fault, source of the 1975 Oroville earthquakes. This fault zone is considered by DSOD to be capable of generating a M6.5 earthquake. This earthquake was adopted for the design of the bypass valve facilities. Attenuation relationships indicate that this earthquake has a peak horizontal base rock acceleration of 0.50g at the site.

2. Foundation Parameters

The foundation rock is predominantly “hard massive amphibolite and hornblend gneiss with a blocky joint system”.

- Assumed friction angle at rock/concrete interface - 45°
- Cohesion at rock/concrete interface - 100 psi

3. Materials

Concrete

Valve structure and powerhouse modifications:
Minimum Compressive Strength f'_c = 4,000 psi

Fill Concrete and other miscellaneous features:
Minimum Compressive Strength f'_c = 3,000 psi

Reinforcing Steel

Minimum yield strength f_y = 60,000 psi

Structural Steel

Valve supports, access bridge, platforms, access ladders and miscellaneous structures: A36 structural steel.

All exposed structural steel and miscellaneous metal will be hot dip galvanized.

Bypass Conduit and Wye Branch Steel: ASTM A516, Grade 70

(Compatible with existing penstock steel)

3.1.2. HYDRAULIC DESIGN

Maximum discharges @ normal max. Res. W. S. El. 527.0:

- New BPV2 — 3000 cfs
- Simultaneous discharge through existing BPV1 on scroll case — 650 cfs

The head losses in the power tunnel - flow bypass system determined as follows:

- Trashrack Losses:

$$h_t = K_t (v_n^2/2g)$$

Where:

v_n = velocity through net trashrack area (ft./sec.)

$K_t = 1.45 - 0.45(a_n/a_g) - (a_n/a_g)^2$

Where:

a_n/a_g = ratio of net area through trashrack bars to the gross area of the trashracks and supports

- Entrance Losses

$$h_e = K_e (v^2/2g)$$

Where:

$K_e = (1/C^2-1)$, C = 0.95 for fully rounded entrance

- Conduit Losses:

$$h_f = 29.1\, n^2 (L/r^{4/3})\, (v^2/2g)$$

Where:

n = Manning's number,

0.012 for cast-in-place concrete conduit,

0.010 for steel pipe with welded joints

L = length of conduit (ft.)

r = Hydraulic Radius (ft.)

- Bend Losses:

$$h_b = K_b\, (v^2/2g)$$

Where:

K_b depends on the ratio of bend radius to pipe diameter and the angle of the bend, taken from published charts.

- Contraction Transition Losses:

$$h_c = K_c\, (v_2^2 - v_1^2)/2g$$

Where:

v_2^2 and v_1^2 = the downstream and upstream velocities respectively

K_c = 0.1 for gradual transitions, 0.5 for abrupt transitions

- Valve Losses:

$$H_g = K_g\, (v^2/2g)$$

Where:

$K_g = 1/C^2$, C = 0.85 for Howell Bunger Valve fully open, (as furnished by valve manufacturer)

In accordance with the ASCE/EPRI Guides, 1989, "Maximum velocities in concrete-lined conduits for outlet works have usually been in the range of 60 to 70 ft/s. For steel-lined conduits of this type, velocities are 70 to 80 ft/s as limited by the availability of the coating of the steel liner to resist these velocities."

3.2 Geotechnical Conditions

Appendix B presents a report prepared by the project geologist. The report contains the results of field geologic mapping and observations and a detailed description of the site geologic conditions.

The foundation rock appears to be very competent, basically sound, hard massive amphibolite and hornblend gneiss. For design purposes, it is assumed that cut slopes in sound rock can be vertical or near vertical where they are to be backfilled with concrete and can be 0.25H : 1V where slopes are to be permanently exposed. Cut slopes in overburden shall be no steeper than 1.5H : 1V Weathered rock cut slopes can be 0.5H : 1V.

3.3 Hydraulic Design

The selection of the 78-inch diameter fixed cone valve for BPV2 and the sizing of the bypass pipeline to optimize the hydraulics of the system to discharge the required 3000 cfs are described in the feasibility report. During final design the theoretical hydraulic capacity of the system was checked using the final design parameters and dimensions.

The final layout of the system differs from the feasibility layout in the following ways:

- The feasibility layout 90-degree junction and abrupt transition of the penstock and bypass line were replaced with a 45-degree wye branch with a gradual transition from the 168 in. diameter penstock to the 96 in. diameter bypass conduit.
- The junction was relocated downstream, resulting in a much shorter length of bypass tunnel.
- The bypass valve centerline was raised by 5 ft. from El. 292.0 to El.297.0.

The net result of these changes was an improvement in the hydraulic performance and the discharge capacity of the bypass system. However, the increases in discharge capacity were not enough to allow consideration of a smaller diameter valve or bypass conduit.

Hydraulic calculations were performed to determine the discharge capacity of the system using the loss coefficients and other hydraulic criteria presented in Section 3.1.2. Head losses were determined for each element of the existing power conduit and the new bypass system including trashrack, entrance, pipeline friction, bends, transitions, and valve losses.

Calculations were performed using an EXCEL spread sheet set up so that the total net head loss under given discharge conditions could be compared with the total available gross static head at the bypass valve. The discharge capacity was then determined for the reservoir full condition (gross static = El. 527 – El. 297 = 230 ft.) by a trial and error process.

The theoretical discharge capacity of the 78-inch fixed cone bypass valve under full reservoir head conditions is 3230 cfs.

A calculation was also performed for simultaneous operation of the new bypass valve and the existing 36-inch bypass valve on the turbine scroll case. With simultaneous operation, velocities upstream of the bypass pipeline are higher resulting in slightly higher head losses than for bypass valve only operation. The additional losses however do not significantly affect the capacity of the new bypass valve. Under full reservoir head conditions, the theoretical capacity of the 36-inch bypass valve is 660 cfs for a total combined capacity of 3890 cfs.

3.4 Bypass Tunnel Design

3.4.1. TUNNEL

1. Geotechnical

Available information from the construction of the existing power tunnel indicate that the bypass tunnel will be excavated primarily in rock that is predominantly hard massive amphibolite and hornblend gneiss with a blocky joint system. However, due to possible changes in the bedrock characteristics along the tunnel alignment, the tunneling conditions and support requirements may vary from station to station. Appendix B contains a more detailed discussion of the geologic conditions.

2. Tunnel Lining

When the tunnel excavation is completed, a steel liner will be installed in the full length of the tunnel and the annular space between the liner and the tunnel wall will be filled with concrete. Lining concrete will have a minimum specified compressive strength at 28 days (f'_c) = 2500 psi. Maximum size aggregate will be 1-1/2 inch. Contact grouting between the steel liner and concrete and between the concrete and rock is required by the specifications.

3. Support Systems

The steel liner and concrete encasement are designed to carry the full permanent loads on the tunnel. The specifications require the Contractor to be solely responsible for the design and installation of any required temporary support of the tunnel. The types, locations, and the extent of the supports necessary for the safety of the tunnel are to be determined by the Contractor, subject to the following limitations:

1. No temporary support may remain closer than one foot to the steel liner.
2. Timber materials may be used only for foot blocks, wedges, and blocking. Wood lagging is prohibited.

Support systems may consist of rockbolts, grouting, shotcrete lining, and steel rib supports.

3.4.2. STEEL LINING AND WYE BRANCH (BIFURCATION)

The steel tunnel liner including the bends and the connection to the existing tunnel liner was designed in accordance with recommendations in ASCE Manual and Reports on Engineering Practice No.79- *Steel Penstocks*.

Steel plate is specified to be ASTM A516, Grade 70 (38,000 min yield), which is compatible with the existing power tunnel liner, ASTM A285 Firebox, Grade B quality steel (27,000 psi minimum yield).

1. Lining Thickness

The steel tunnel lining was designed for the more critical of full internal pressure from the reservoir at maximum elevation or external pressure throughout its length. External pressure was assumed to be equivalent to the pressure created by a column of water extending from the tunnel to the ground surface, but no greater than full reservoir pressure.

Internal Pressure Thickness Requirements: The design internal pressure in the bypass line is equivalent to the static head under full reservoir (El. 527) plus an allowance for overpressure due to surges. The design internal pressure at the bypass pipe centerline (Minimum El. 292) is 130 psi. With an allowable tensile stress of 23,300 psi for the steel plate, the calculated required thickness is 0.27 inches. Rounding this value to the available plate thickness of 3/8 inch will provide a corrosion allowance of about 40 %.

External Pressure Thickness Requirements:

The maximum ground surface elevation above the bypass pipe is about El. 422 or 56 feet above pipe centerline. The design external pressure is equivalent to a 56 ft. high column of water or 24 psi.

The critical buckling pressure under external pressure loading was estimated by extrapolation from the Jacobsen Formulation curves for critical buckling presented in the ASCE publication: "Steel Penstocks". This formulation is based on the theory that a single buckling lobe is formed, considering a gap between the steel and the surrounding concrete due to concrete shrinkage and temperature difference. The gap can realistically vary from 0 to 0.001 times the pipe radius. The critical buckling pressure for the 3/8-inch plate thickness (diameter to thickness ratio of 256) was determined to be approximately 40 psi. This value is greater than the assumed external design pressure.

The internal pressure thickness requirements therefore control.

Handling Thickness Requirements: The minimum steel liner plate thickness required for handling was determined by the following formula:

$t = (D + 20)/400$
D = internal diameter, in.
t = plate thickness, in.

For the 96-inch diameter pipe the minimum required thickness is 0.29 inches, which is less than the 3/8 thickness provided.

2. Wye Branch

The connection of the steel bypass tunnel liner to the existing 168-inch diameter power tunnel liner is a 45° wye branch with an outlet leg diameter of 138 inches. Design of the wye branch was in accordance with AWWA-M11. Dimensions and thicknesses of reinforcing plates (clamps) were determined using Nomograph 13-7. The design wall thickness of the main pipe and branch line is 1 inch. The reinforcing plates are 4 inches thick.

The Specifications call for the contractor to verify the design shown on the contract drawings and to complete the detailed design in accordance with AWWA guidelines and the ASME Code.

3.5 Structural Design of Bypass Valve Structure

3.5.1. Description of Proposed Bypass Valve Structure

The bypass valve structure consists of the following elements listed from upstream to downstream:

1. The guard valve chamber. This chamber extends from floor level El. 290.5 to the top deck at El. 348.0. The pipe connecting the guard valve and the bypass valve passes through the downstream wall of this chamber. A thrust collar that transmits thrust due to hydraulic pressure occurring under closed valve conditions to the structure is attached to this wall.
2. The fixed cone bypass valve chamber. This chamber is fully open to the air at the top to assure adequate air supply to the valve. The chamber walls extend up to El. 322.0 to protect the valve from debris carried by floodwater.
3. The 18 ft. diameter, 18 ft long steel lined deflector hood.

The lower part of the structure is cast into a notch excavated into the competent rock downstream of the new bypass tunnel and is well keyed into the rock foundation. Above approximately El. 310 the structure is a free standing tower.

Figure 1-3 and Figure 1-4 are copies of the bidding drawings showing the outlines of the structure and the equipment arrangement. The following tabulation summarizes the principal elevations and dimensions:

Top Deck Elevation	El. 348.0
Centerline Of Bypass Valve:	El. 297.0
Floor Of Valve Chambers:	El. 290.5
Valve Diameters:	78 inch
Guard Valve Chamber Dimensions:	11 ft. long x 20 ft. wide
Bypass Valve Chamber Dimensions:	10 ft. long* x 20 ft. wide
Deflector Hood Dimensions:	18 ft. dia. x 18 ft. long

* This dimension must be verified by the valve manufacturer to assure that the end of BPV2 is in the correct position relative to the deflector hood.

3.5.2. Loading Combinations

The bypass valve structure was designed to resist the following loading combinations:

- Normal Loading
  - Dead load of concrete.
  - Weight of valves and miscellaneous equipment.
  - External water load due to tailwater at normal level.
  - Thrust from thrust collar on wall between guard valve and bypass valve chambers with bypass valve closed.
- Unusual (Flood) Loading
  - Same as normal condition except the external water load will be assumed at the top of the bypass structure. This condition was approached during the 1997 flood. If the water surface exceeds this level, the guard valve chamber will fill with water and pressure will equalize.
  - The structure could be impacted by large debris consisting of trees coming over the dam spillway and large boulders dislodged from the plunge pool and dam abutments during high spill flows. The design will also address these factors.
- Extreme (Earthquake) Loading
  - Normal loading conditions plus the design earthquake ground motion described in the Section 2 - Criteria.
- Access Bridge Live Load: AASHTO H20

  Check bridge capacity for weight of valves.

3.5.3. Design of Reinforced Concrete Elements

Determination of slab and wall thicknesses was based on the dimensional requirements and experience with similar type structures. Thicknesses were checked by calculating shears and moments at critical locations under the controlling loading condition and determining that shear stress values were within acceptable levels and that bending moments could be accommodated with a reasonable amount of reinforcing steel.

Normal Condition: Under normal conditions, loads on the structural elements are generally nominal and can be accommodated by the code required temperature steel. An exception is the wall between the guard valve and bypass valve chambers where the thrust collar imposes a significant horizontal force around the pipe penetration at the center of the wall. Bending moments due to this force were determined, and reinforcing requirements were computed in accordance with ACI requirements.

Horizontal Reinforcing in Walls and Foundation Slab: External water load under flood conditions (including uplift under the foundation slab) controls the design of the horizontal reinforcing. Bending moments due to this load was computed at various levels and horizontal reinforcement was provided in accordance with ACI requirements. Shear stresses in the walls due to this loading were computed and determined to be at levels below that requiring shear reinforcing.

Vertical Reinforcing of Tower Section:

The vertical reinforcing in the tower section is controlled by earthquake forces or flood impact forces which produce high bending moments at the bottom of the free standing part of the tower just above the point where it is embedded in the surrounding rock. Earthquake forces, shears and bending moments were computed by a dynamic finite element analysis described in the following section.

3.5.4. FINITE ELEMENT ANALYSIS OF TOWER SECTION

1. Finite Element Model

A finite element mathematical model consisting of three-dimensional solid elements was developed to represent the freestanding portion of the structure. Since the structure is well keyed into the surrounding competent foundation rock, the lower part of the structure was not included in the model and the freestanding portion is assumed to have a fixed end moment at its interface with the embedded part of the structure.

The model extends from the top deck, El. 348.0 down to El. 305.0, which is well below the level of the embedment of the structure into the foundation rock. The surrounding rock above El. 305 is not included in the model and thus the support from this rock is neglected in the analysis.

A mesh plot of the model is shown on Figure 3-1. The model consists of 241 solid elements connected by 738 nodes, requiring the solution of 1578 equations. The nodes at the base of the model at El. 305 are fully constrained.

2. Design Earthquake

Seismic ground motions representing the design earthquake were obtained from accelerograms of earthquakes having similar characteristics and scaled to a peak acceleration of 0.50g.

3. Computer Program

The computer program used for the analysis is SADSAP, Static And Dynamic Structural Analysis Program. Edward L. Wilson, Professor emeritus of the University of California, Berkeley developed the SADSAP program during the past ten years.

4. Finite Element Analysis and Results

A static and dynamic time-history analysis was performed on the model. Static loading consisted of the dead weight of the structure. Other static loads such as weight of equipment and the bridge seat reaction are relatively minor and were neglected. Dynamic input consisted of time-history accelerograms representing horizontal and vertical components of the design earthquake.

Analysis results of interest consist of time-histories of all components of displacement and stresses at all nodal points in the model. For illustration Figure 3-2 and Figure 3-3 show time histories of the horizontal displacement of a point on the top deck of the structure in the longitudinal X (upstream/downstream) and transverse Y directions respectively. To illustrate the stress output, Figure 3-4 shows a time-history plot of vertical stresses at a point at the base of the model along the centerline. Stresses at this point vary from 50.6 psi tension at time 7.465 seconds and 136.7 psi compression at time 8.380 seconds. Note that stresses between time zero seconds and one-second ramp up to about 40 psi compression and hold at that level until time 3 seconds. This represents the manner in which the program applies the dead load stresses. The earthquake begins at time 3.000 seconds and dynamic loading is superimposed on the dead load.

5. Shears and Bending Moments

Two horizontal sections through the model were selected for detailed examination: El. 305 at the base of the model where transverse bending moments would be maximum and El. 322 where longitudinal bending moments would be maximum. The time-history results were then examined to determine the time instant at which maximum tensile stresses occur at these two locations. Maximum tensile stresses occur at El. 305 at 8.365 seconds and at El. 322 at 8.675 seconds.

“Snapshots” of stresses at these two time instants were then obtained using one of the program’s post processing routines. Vertical stresses were converted to forces by multiplying by the appropriate tributary areas and these forces were multiplied by their respective lever arms to determine the total bending moments about the centerline of the section. The maximum transverse bending moment at El. 305 is 161,500 kip-inches and the maximum longitudinal bending moment at El.322 is 74,400 kip-inches.

The resulting bending moments were then used to determine the required vertical reinforcing steel in the structure in accordance with ACI requirements. The vertical reinforcing steel is carried down into the embedded portion of the structure to assure adequate transmittal of load from the freestanding part into the embedded part.

Shearing stresses were converted to horizontal forces by multiplying by the appropriate tributary areas and these forces were summed to determine the total horizontal force at each section. Shear stresses levels were examined and found to be well below the allowable shear stress for unreinforced concrete. No further processing of shear stresses was therefore necessary.

3.5.5. FLOOD IMPACT FORCES

Flood forces consist of differential water pressures on the exposed tower walls due to the velocity of the flowing floodwater and the impact of logs and other debris floating at or near the water surface.

The structure was checked for resistance to simultaneous occurrence of the following assumed flood impact forces:

- Differential pressure on opposite wall surfaces equivalent to 10 feet of head, water surface at top of tower, El. 348.0
- Debris impact equal to 1000 lb / linear ft. of exposed wall surface applied at the top of the tower, El. 348.0

Shears and bending moments due to the assumed loading were computed at the same critical locations as for the earthquake forces described in the previous section.

The results of the calculations indicated that maximum shears and moments in the transverse direction at El. 305 were less than those computed due to earthquake forces. In the longitudinal direction at El. 322, shears and moments were slightly higher (about 3%) than those computed due to earthquake. The reinforcing requirement in the upstream and downstream walls was increased accordingly.

3.5.6. STABILITY ANALYSIS

Since the structure is well keyed into the foundation rock, overturning stability is assured provided adequate reinforcing is provided to tie the freestanding portion into the embedded portion. Likewise transverse sliding stability is assured.

Horizontal driving forces on the structure tending to cause sliding in the longitudinal downstream direction include thrust from the hydraulic force on the thrust collar under closed valve conditions (normal condition) and earthquake (extreme condition).

Earthquake forces were determined by combining the total shearing force computed at El. 305 by the finite element analysis with the inertial force on the remainder of the structure between that level and the foundation.

The factor of safety against sliding was computed as the ratio of the horizontal driving force to the resisting force. Resisting forces were determined by multiplying the weight of the structure times the assumed friction coefficient of Tan45° and neglecting the cohesion on the foundation and along the sidewalls of the structure cast against rock

The resulting factors of safety against sliding are 10.2 for normal loading conditions and 1.6 for the extreme condition. These values are well above acceptable levels, particularly considering the very conservative assumption of no cohesion resistance.

Flotation stability was also checked by comparing the weight of the structure to the weight of displaced water under maximum flood conditions (structure completely submerged). The factor of safety against floatation is 1.6. This calculation also neglects the effect of cohesion along the sidewalls cast against rock.

3.6 Structural Modifications in the Powerhouse

3.6.1. Enlargement of Valve Chamber

1. General

Space requirements for the new TSV, cooling water and bypass pipelines and valves and other accessories require that part of the upstream (north) powerhouse wall in the valve chamber be relocated further upstream. The location of the inside surface of the relocated wall will depend on the final dimensions of valve that will be furnished by the valve manufacturer and included with the contractor's bid. Based on preliminary dimensions provided by potential TSV manufacturer's, the inside surface of the wall around the penstock penetration will need to be moved approximately 3-1/2 ft. upstream.

2. Design of Existing Upstream Powerhouse Wall

The original design of the powerhouse provided for a portion of the upstream wall around the penstock penetration to be blocked out to allow for installation of a hemispherical test head and pressure testing of the steel liner prior to tunnel concreting and completion of the powerhouse. A reinforced wall was construction to fill the blockout following removal of the hemispherical bulkhead. Reinforcing in the wall at the sides and above the blockout was designed to support the entire powerhouse structure during the construction process. All or part of the concrete placed in the blockout can therefore be removed to provide for the TSV installation without affecting the structural integrity of the powerhouse.

The wall at the penstock penetration was placed against the excavated rock upstream of the powerhouse. According the as-built drawings, the powerhouse excavation in rock has excavated side slopes of 1 horizontal to 10 vertical and the upstream wall thickness at the penstock penetration varies from 5.5 ft. at floor level to 6.8 ft. at the centerline of the penstock.

3. Removal and Replacement of Wall

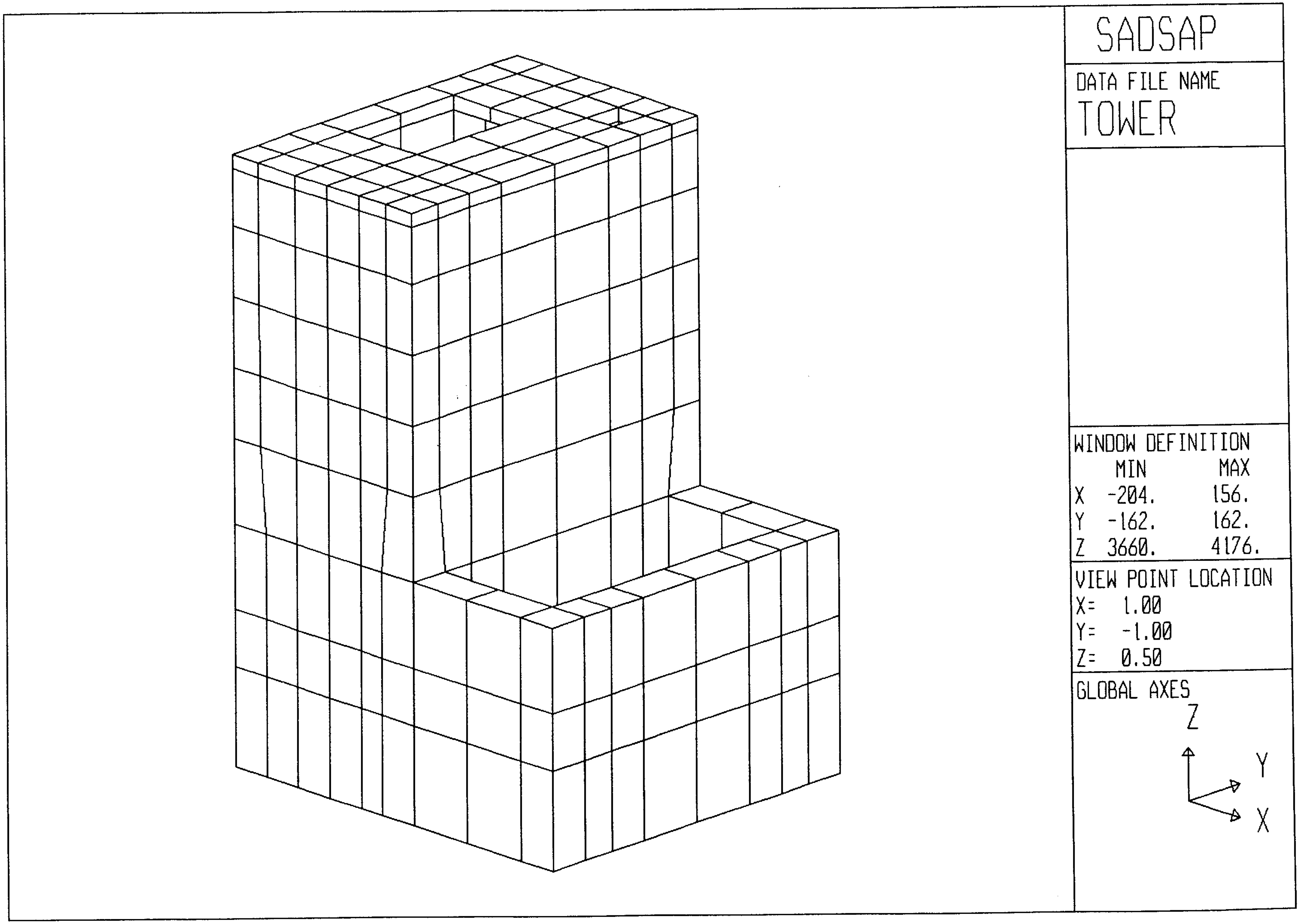
A portion of the concrete wall filling the blockout will be removed to allow a minimum of two feet of clearance around the penstock and a sufficient distance upstream to allow for the required clearances and an additional 1-1/2 ft. to be replaced with a reinforced concrete section. Demolition will include removal of a section of steel penstock up to the limit of wall removal. Saw cutting around the perimeter of the concrete removal will be required.

3.6.2. Enlargement of Hatch Openings for TSV Installation

The TSV will be lowered though the runner removal hatch openings provided through the three powerhouse floor levels (Elevations 348, 324 and 304). The openings are 14 ft. square, which provides insufficient space through which to lower the valve. A temporary notch will be saw-cut through each slab at the northeast corners of the hatch openings. Based on preliminary dimensions from potential valve manufactures the notch will be 3.5 ft. wide by 6 ft. long.

Following valve installation, reinforced concrete will be replaced in the notches. Drilled-in resin dowel bars will be used to reattach reinforcing bars and waterstops will be provided around the perimeter of the top deck opening.

Figure 3 - 1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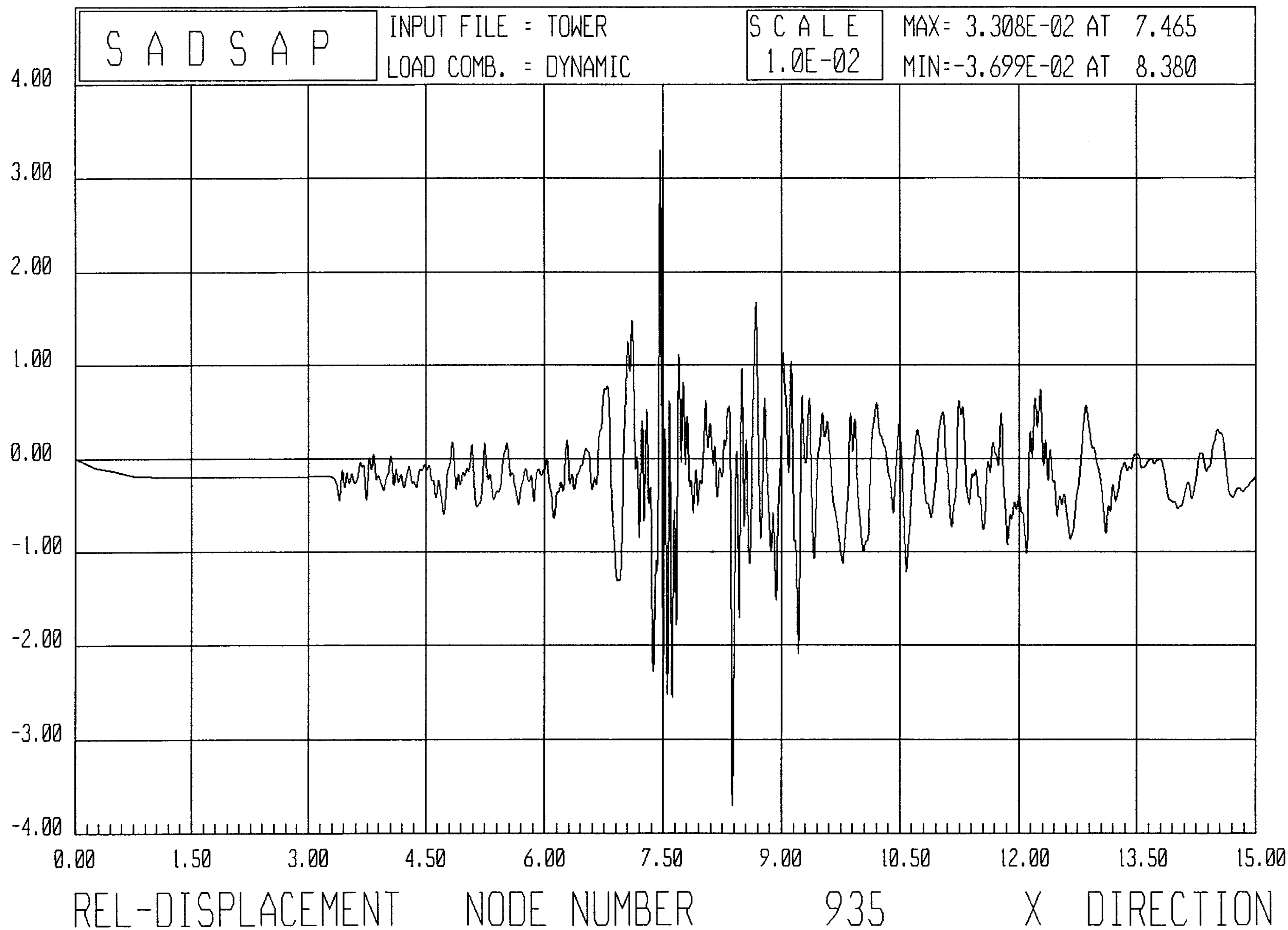
Z
Y
X

Figure 3 - 2



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4.50
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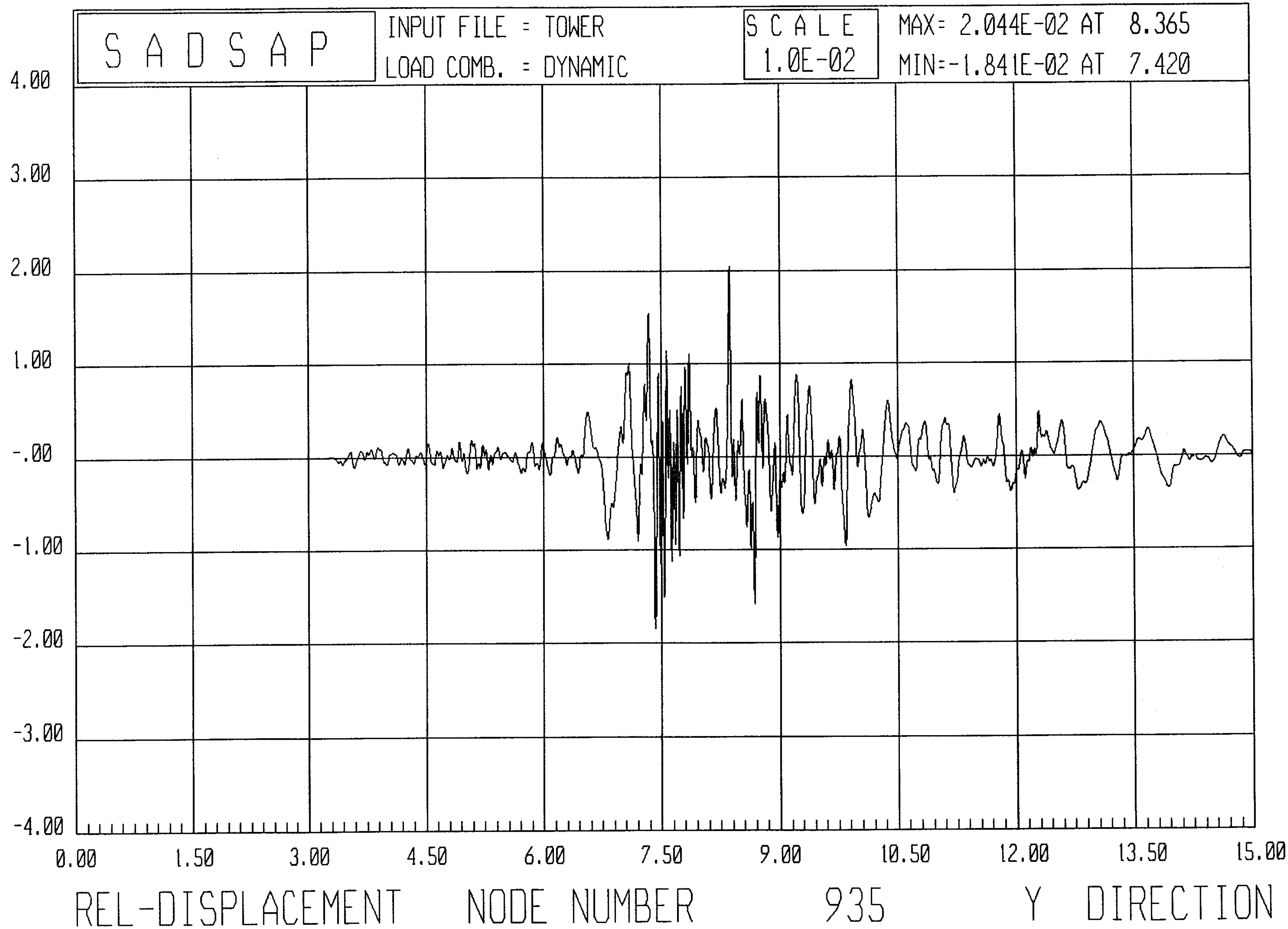
Figure 3 – 3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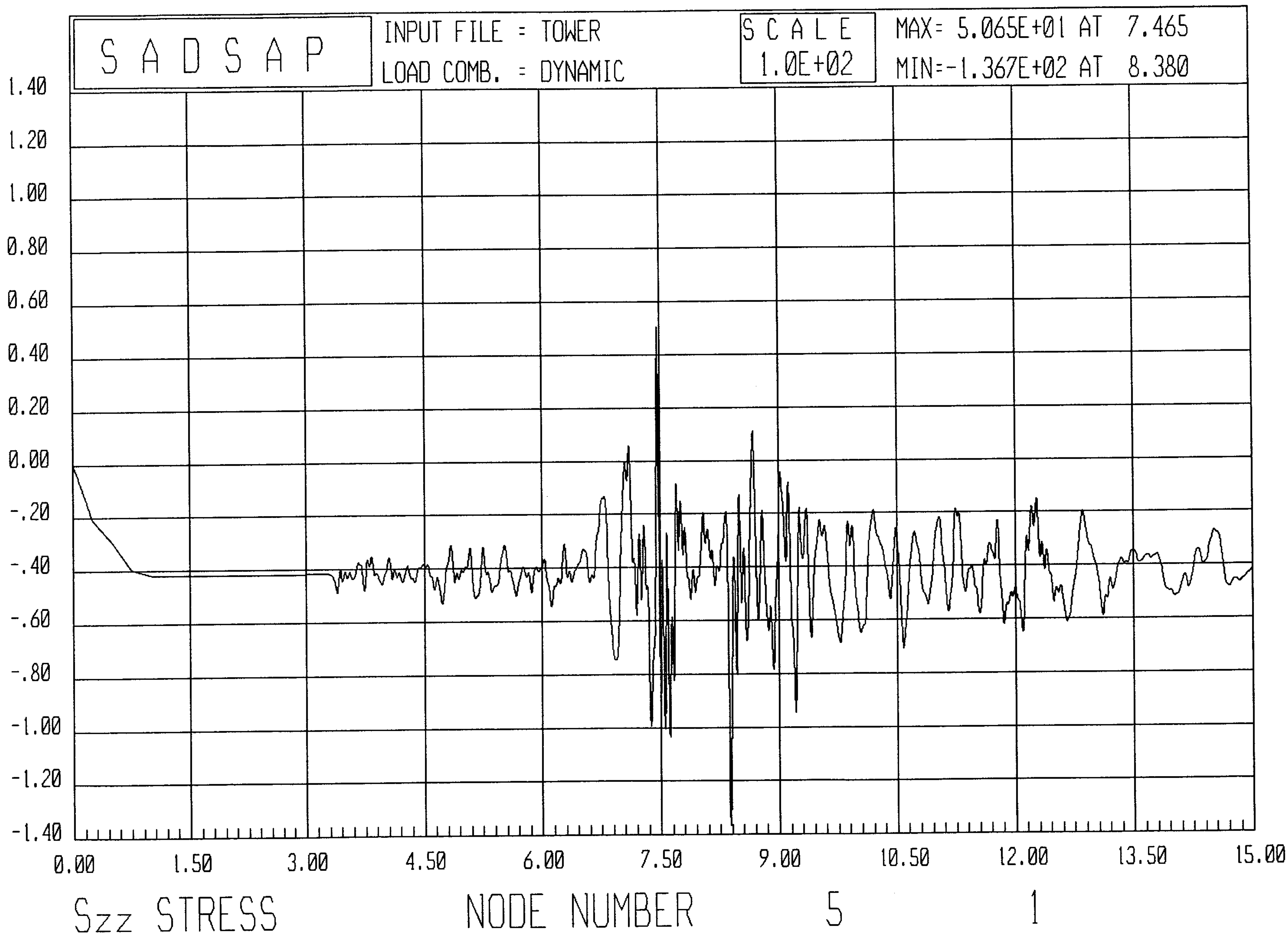
REL-DISPLACEMENT NODE NUMBER 935 Y DIRECTION

Figure 3 - 4



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1.50
3.00
4.50
6.00
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13.50
15.00
Szz STRESS
NODE NUMBER
5
1

4. FINAL DESIGN –MECHANICAL FEATURES

4.1 Mechanical Design Criteria

4.1.1. DESIGN LOADS

In the design of the valves and their operators, consideration will be given to the maximum individual loads and combination of loads to which the equipment and the components may be subjected. For purpose of application of allowable working stresses the following loading conditions will be considered.

- Normal Maximum Hydrostatic Pressure
  – Reservoir Water Surface El. 527.0
- Maximum hydrodynamic forces which may occur during the operation: A total pressure of 130 psi representing hydrostatic pressure plus surge due to sudden shutdown of the unit because of a forced outage
- Combination of forces stated above plus seismic loading

4.1.2. MATERIALS

The following materials will generally be used for the main components of the valves:

ASTM – A36 - Structural Steel
ASTM – A285 – Pressure Vessel Plates
ASTM – A516 – Pressure Vessel Plates
ASTM – A325 - High Strength Steel Bolts, Nuts and Washers
ASTM – A240 – Type 304L – Corrosion Resisting Steel
ASTM - A276 – Type 304 and Type 304L – Stainless Steel

4.1.3. WORKING STRESSES

The basic allowable working stress under normal loading conditions will be $S_{all} = 0.40S_y$ (40% of yield point) for the valves and $S_{all} = 0.20S_u$ (20% of ultimate strength) for mechanical components.

For extreme loading conditions, the allowable design stresses will be limited to 85% of the yield point of the material used.

4.2 Equipment

The valves and operators and the hydraulic system will be designed by the manufacturers in accordance with criteria presented in the specifications and described herein.

4.2.1. VALVES AND OPERATORS

Valves will be designed in accordance with AWWA (American Water Association) and ASME (American Society of Mechanical Engineers) codes and standards. Hydraulic cylinders will be designed in accordance with Section VIII, Division 1 - Pressure Vessels, of the ASME code. The allowable stresses under momentary overload condition will not exceed 85 percent of the yield point of the material used. Momentary over loads will be assumed to be not less than 2.50 times the normal operating pressure or load.

4.2.2. HYDRAULIC SYSTEM

The hydraulic system components will be designed in accordance with the applicable requirements of ANSI B31.1.0, Power Piping, and the JIC Hydraulic Standards for Hydraulic Equipment. Fluid velocities will be limited to 15 feet per second.

4.3 Turbine Shutoff Valve, Operators and Controls

4.3.1. DESCRIPTION

The turbine shutoff valve (TSV) will be a butterfly type valve, rubber seated, hydraulically operated, designed and constructed for operation under maximum dynamic head and maximum flow conditions. The valve will be foot-mounted with a low friction loss disc structure complete with piping and controls, companion flanges and all necessary auxiliaries and devices.

The TSV diameter will be 168 inches (14 feet) and the valve will be designed to minimize head loss in the full open position. The TSV will also be provided with an automatic 6 in. diameter air/vacuum relief valve to be mounted downstream of the TSV. The air/vacuum relief valve will be designed to permit exit or entrance of air during filling or emptying the spiral case when the TSV is in the closed position.

4.3.2. OPERATOR

The turbine shutoff valve will be operated by a double-acting hydraulic cylinder with floor mounted trunnion and connecting linkage. The hydraulic cylinder will be equipped with an adjustable opening and closing speed control valve in a range from 3 to 8 minutes. This will accommodate the required closing time, which will limit the turbine runaway speed and at the same time limit the pressure surge in the tunnel that may result from a too fast closure rate.

The hydraulic cylinder will be controlled and operated by a hydraulic power unit (HPU) to be located above the TSV on the powerhouse Turbine floor, El. 304. The hydraulic power unit will be composed of an oil sump, two electric motor driven oil pumps, a stand-by hand pump and the required control valves and accessories. The HPU will also include a set of hydraulic accumulators to serve as a source of stored energy capable of operating the TSV during the loss of electrical power. The hydraulic accumulators are sized for operation of the TSV with sufficient oil pressure capacity to operate the valve cylinder through one full open and close stroke.

The hydraulic power unit is also designed and sized to operate the new 78-inch diameter fixed cone valve (BPV2 and the new 78-inch guard valve) at the new flow bypass structure.

4.3.3. CONTROLS

The new turbine shutoff valve and its associated controls will provide a safe and reliable flow shutoff device to protect the generating unit during an emergency shutdown and facilitate unit dewatering and maintenance. The TSV will have the following modes of operation:

1. Normal Opening

The TSV must always be opened under balanced (no flow) head conditions. The normal opening will start after hydrostatic pressure is equalized on both sides of the valve disc. Prior to balancing the head, it must be verified that the draft tube bulkheads have been removed and the turbine wicket gates are closed. The pressure equalization will be accomplished by opening the 6-inch diameter filling valve in the TSV bypass line. Pressure transducers at the downstream side of the TSV in combination with the pressure signal from the upstream side will energize the TSV “OPEN” circuit upon pressure equalization, enabling the opening of the TSV. The normal opening of the TSV will be performed manually from the local control cabinet.

2. Normal Closing

The TSV can be closed either automatically or manually, depending on the position of the selector switch, under flow or no-flow conditions.

3. Emergency Closing

This closure will be performed automatically by the unit supervisory instrumentation by the following initiated closure signals:

a. Loss of governor pressure – 65 QP

b. Loss of governor oil level – 65 QL

c. Unit vibration – 96 Y

d. Turbine and/or generator bearing excessive high temperature - 38

e. Power house flooding – 33 WE

f. Unit runaway (wicket gates did not close) - 12

Each of these emergency closure signals will cause the TSV to close at the predetermined closure rate. The TSV will not have counterweights, and to affect the emergency closure in the absence of a power supply, the hydraulic accumulators will provide the stored energy and be capable of closing the TSV under full flow and maximum head conditions.

In an emergency closing, the intake gate will remain open. The intake gate will only be closed for tunnel dewatering for inspection and maintenance. This will be done manually from the local control panel.

4.4 Bypass Valve, Operators and Controls

4.4.1. DESCRIPTION

The bypass valve (BPV2) will be a 78-inch diameter fixed cone valve (Howell-Bunger type) designed for flange mounting on the end of the 78-inch diameter connector pipe downstream of the guard valve and discharging through the deflector hood. The valve will be designed to operate at any position between fully open and fully closed with a maximum discharge capacity of 3000 cfs. The valve will be housed in a reinforced concrete chamber sized to provide the required minimum clearances around the valve as recommended by the valve manufacturer. The centerline of the valve will be at El. 297.0 and the floor of the valve chamber will be at El. 290.5, or 6.5 ft. below the valve centerline. The top of the valve chamber will be open to the atmosphere to provide adequate air supply for the valve during operation. A deflector hood will be provided downstream of the end of the valve to reduce spray and provide satisfactory dissipation of energy of the discharged water. The hood will be steel lined, 18-ft. in diameter and 18-ft. long. Access ladders will extend from the top of the outlet structure, El. 348 down to the guard valve and BPV2 chamber floors El. 290.5. A sump pump will be provided in the guard valve chamber.

4.4.2. VALVE OPERATOR

The bypass valve will be operated by a pair of hydraulic double acting cylinders deriving their hydraulic oil power from the hydraulic power unit (HPU) located in the powerhouse above the TSV. Oil pressure for the valve cylinders operation will be delivered by stainless steel hydraulic piping properly sized to minimize friction loss. The HPU will share the same components as for the TSV including the set of hydraulic accumulators to serve as backup energy source during the loss of electrical power. The hydraulic accumulators will be sized to operate the bypass valve cylinders through a full open and close cylinder stroke.

4.4.3. CONTROLS

The bypass valve controls will be capable of automatic remote control from the Agency's Colgate Powerhouse and from PG&E's Wise Switching Center and local control operation from the control panel located at the HPU in the powerhouse. The valve control system will be based on the use of a programmable logic controller (PLC), which will be able to perform the required calculations and logic control to comply with the flow control regime for the Narrows 2 hydro power plant, (for details refer to Section 2).

Valve controls will be designed for a maximum opening rate of 2 minutes from fully closed to fully open.

The bypass valve will be manually controlled from the control panel in the powerhouse. The main control functions will include valve "OPEN", "CLOSE" and "STOP".

The bypass valve controls will include a 4 to 20-mA position transducer, extreme position open-close limit switches.

4.4.4. WARNING ALARM SYSTEM

An alarm system will be provided to sound a warning when BP2 is about to open. Warning signs will be posted at appropriate locations in the vicinity of and on the valve structure.

4.5 Guard Valve

4.5.1. VALVE DESCRIPTION

The guard valve will be a 78-inch diameter bonneted knife gate valve, or bonneted slide gate, designed for unrestricted flow (full bore configuration). The valve will be flanged type and located just upstream of BPV2. The guard valve will serve as a shutoff device to stop flow through the bypass pipe in case of a malfunction of the bypass valve and also to facilitate BPV2 inspection, maintenance and repair. The guard valve will be able to close and open under balanced and unbalanced head conditions. A 6-in. diameter automatic air/vacuum relief valve will be installed in the pipeline immediately downstream of the guard valve. The air/vacuum valve will admit air during dewatering of the downstream pipeline to prevent sub-atmospheric pressures developing in the line. The air vacuum valve will also permit exit of air during filling of the downstream pipeline.

4.5.2. VALVE OPERATOR

The guard valve operator will consist of a double-acting hydraulic cylinder deriving its hydraulic oil power from the HPU located in the powerhouse near the TSV. The HPU is the same unit that serves the TSV and BPV2. Oil pressure for the valve cylinder will be delivered by stainless steel hydraulic piping properly sized to minimize friction loses.

4.5.3. CONTROLS

The guard valve will be controlled manually from the control panel in the powerhouse. The main control functions will include commands for valve "OPEN" and "CLOSE" . The valve controls will include two limit switches, one to indicate valve closed position and the other to indicate valve open position.

5. FINAL DESIGN - ELECTRICAL FEATURES

5.1 Plant Valve Control System

The hydraulic power unit will contain a programmable logic control (PLC) to perform the required calculations and control logic for ramping up or down the unit without exceeding operating requirements. The PLC will enable the operator to change the parameters from the existing supervisory control system.

The hydraulic operating system will operate the TSV, BPV2 and the guard valve. The hydraulic control logic will include manual pump and valve controls and in the automatic mode, the PLC will control the oil pumps and BPV2.

The 125v DC control feed will be from the existing battery system. The PLC will step 125v DC down to 24v DC.

The 120vac uninterruptible power supply system will operate the flow meter and valve position transmitters.

The control functions will be integrally mounted in a control enclosure with local and automatic control operations. Transducers will be used to control pressure and level operations. These devices will pump shutdown on low oil level or pressure and transmit alarm and shutdown to the plant supervisory control system.

The TSV, BP2, and the guard valve will be provided with limit switches.

BPV1 and BPV2 will also be provided with continuous position transmitters, transmitting a 4 to 20 mAdc signal (0 - 100%).

The hydraulic Power Unit control panel will be NEMA Type 12 enclosure.

- Terminal blocks will be Din Rail mounted
- Indicating lights, pushbuttons, and control “HOA” switches will be heavy duty type
- Meters will be LED Type.
- Lamp cutout switch

5.2 Power Supply

The AC power sources for the hydraulic power unit; TSV and BPV2 will be fed from existing 208 volt, 3 phase, 4-wire distribution switchgear. The control power for the TSV and the BPV2 system will be fed from the PLC 24v system. The BPV2 structure will be provided with normal lighting and power for the sump drain pump.

5.3 Motors

Motors will be of the totally-enclosed, non-ventilated, high-starting torque, low starting current type for full voltage starting. The motors will be suitable for operation on 208 volt, 3-phase, 4-wire, 60 Hz current, have Class F insulation, and a motor frame with all dimensions in accordance with the latest revised NEMA Standards.

The motor horsepower requirements will be determined by the hydraulic power unit manufacturer.

5.4 Grounding

All equipment will be provided with a grounding connection to the existing grounding grid.

5.5 Cables

Power, lighting and control wire will be single or multi- conductor copper with cross-linked polyethylene XHHW insulation rated 600 volt AC and a temperature rise of 75º C.

Low voltage cables will use solderless compression or insulated ring type lugs.

Shielded instrumentation cable will be single pair, insulation rated 300 volt AC.

5.6 Conduit System

Power, lighting and control cables to individual load and devices will run in cable trays and rigid galvanized steel conduits. Instrumentation cables to devices will run in rigid galvanized steel conduits.

Electrical conduits will be sized in accordance with the requirements of NEC.

6. CONSTRUCTION CONSIDERATIONS

6.1 Construction Plan

This section describes a program and procedures for construction of the Narrows 2 Power Plant Flow Bypass. The plan presented below was developed by our project team based on the plans and specifications and experience in planning, scheduling and cost estimating for similar projects. However, the contractor performing the work may propose different programs or procedures depending on the contractor's resources and ideas.

Critical considerations in construction planning and scheduling include the lead-time required for valve procurement and the short period of time that the Narrows 2 Powerplant can be shutdown without adversely affecting the Agency's power revenues.

The work at site will be performed in three phases comprising Pre-Shutdown, Shutdown and Post Shutdown phases each of which is described in detail in the following subsections.

6.1.1. CONSTRUCTION CONSIDERATIONS

1. Stream Flow

The new turbine shutoff valve and wye branch will be installed during a scheduled shutdown of the powerhouse. Scheduled shutdowns occur in the period September 10th through November 30st each year during which downstream flows are maintained by operation of the Narrows 1 powerhouse supplemented, if necessary, by water siphoned or pumped over the dam. Maintaining stream flow during scheduled shutdowns is the responsibility of the Agency and is not part of the construction contractor's project work.

2. Access Roads

Road access to the project is via State Route 20 about 14 miles east from Marysville, thence about 8 miles via partially unpaved county road ending with 2 miles of paved access road to the powerhouse. A locked gate controls access to the project area.

The existing access road ends at a bench upstream of and level with the top of the existing powerhouse. This bench will be expanded to include the site of the wye branch access shaft and to provide working area for equipment servicing the construction work and valve installation.

Permanent road access to the base of the new valve structure and outlet channel will not be required. Design documents show a temporary road to the base of the valve structure to service construction work. However, the contractor may choose alternate methods of servicing this area, subject to permitting requirements and required approvals.

In the powerhouse, some hatch openings will be temporarily enlarged to allow installation of the new valve. The openings will be restored to their original dimensions after the valve is installed.

3. Laydown Areas

Flat Areas located adjacent to the intersection of powerhouse and intake access roads, about half a mile from the powerhouse, may be used for temporary shops and offices, equipment and material storage, and a small concrete batch plant. Temporary facilities will be provided to collect and treat wastewater and runoff. When work on the project is complete all construction materials and temporary structures will be removed and the areas will be cleaned and graded.

4. Special Considerations

The project incorporates a number of factory built components, the largest of which are expected to be the turbine shutoff valve and the penstock wye branch. It will be the contractor's responsibility to choose the configuration of shipments, the transportation method and route and to obtain the necessary permits. Some final assembly of wye branch components is expected to be performed in the laydown area at the jobsite after pieces are delivered.

6.1.2. PHASE I – PREPARATION (PRE-SHUTDOWN)

1. Mobilization and Access

After required contract documentation is completed, work at the site will commence with the construction of temporary offices and facilities, grading of laydown areas, excavation of the work platform at El. 348 and establishment of access to the areas of the valve structure and outlet channel.

A large construction crane will be stationed on the bench behind the powerhouse, adjacent to the retaining wall. Initially the crane will be used to support excavation and concrete construction of the Bypass Valve Structure and Bypass Tunnel. Following setting of the valves and erection of the Access Bridge, the crane will be repositioned to support the Wye Branch Access Shaft excavation, and then used to set the wye branch following shutdown.

2. Bypass Structure and Tunnel

The construction program for the bypass is based on the assumption that no water will be spilled from the dam during the construction period. Any abnormal rise of the water elevation in the river around the work area while work is in progress may adversely impact the work and the contractor should be prepared for such events.

There is some risk of spill over Englebright dam during winter and spring months that could cause excessive flow in the river channel adjacent to the Work. The Agency has control of releases from upstream facilities and will make every effort to minimize spilling at Englebright Dam during the construction period; however there will still be the risk of spill during major storms. The Agency will provide timely forecasting of flooding and the possibility of spill at Englebright. The Contractor must schedule all work that may be affected by spill and excessive flow in the river channel adjacent to the Work to minimize the risk of damage to the Work or to the Contractor's equipment and facilities

During the course of construction water infiltrating into the excavation from normal river levels and ground water will be collected in a retention pond in the new outlet channel. Clean water will be returned to the river. Excess infiltration will be controlled by the construction of barriers as necessary.

The contractor will submit a detailed excavation and blasting plan for approval before work is commenced. The plan will include, in addition to other details, bench heights, drilling patterns and explosives distribution. As work proceeds, results will be monitored and the plan adjusted as necessary to avoid damage to existing facilities or disruption of powerhouse operation.

Construction of the bypass will commence with removal of boulders and other loose material from the site of the valve structure and outlet channel to expose the solid rock surface. Open cut rock excavation to design dimensions will then proceed by drilling and blasting which will be performed in accordance with the contractor's pre-approved blasting plan. Smooth blasting methods will be used on vertical rock faces to minimize overbreak and to leave a relatively even surface against which concrete will later be poured. Material from the excavation will be loaded on trucks and hauled to an approved spoil dump.

After open cut excavation is complete, the bypass tunnel will be excavated from its portal at the upstream end the valve structure upstream to the perimeter of the wye branch access shaft location. Since this tunnel is less than 50 feet long and about 10 feet excavated diameter, it is unlikely that the contractor will mobilize a large tunneling plant. Drilling and blasting operations will probably be performed using manually operated jackleg drills or a small hydraulic jumbo with mucking and general support performed by a conventional rubber tired front-end loader. Geologic reports indicate rock quality is good, and only random rock support is expected.

After tunnel excavation is complete the steel tunnel liner will be installed and welded and the annulus between the excavated surface of the tunnel and the outside of the steel liner will be backfilled with concrete. Grout will then be injected to fill any voids which may have formed outside the steel liner and drain holes will be drilled to relieve any build up of pressure around the tunnel.

When work on the bypass tunnel is complete the concrete valve structure will be constructed. The work will be performed in a series of lifts with concrete poured against the exposed rock surface of the excavation. If necessary to meet schedule requirements, blockouts will be left in the walls at the base of the structure to allow later installation of valves and appurtenances which will be embedded in second stage concrete. The hood liner, which has a minimum 12 feet diameter opening, will be installed with the first stage concrete.

After valve tower concrete is complete, ladders and handrails will be installed, the permanent access bridge will be erected and the guard and bypass valves will be installed. Hydraulic piping for operation and control of the valves will then be installed from the Hydraulic Power Unit in the powerhouse.

Work will be suspended at this point until the powerhouse is shutdown and the penstock dewatered. Completion and testing of the bypass and valves will be coordinated with work on the wye branch installation and turbine shutoff valve in Phase II.

3. Wye Branch

Phase I excavation of the wye branch access shaft will commence after work on the bypass tunnel and bypass structure is substantially complete. The powerhouse will be in operation while this phase of the shaft excavation is performed and the same precautions used during the valve structure excavation to avoid damage or disruption will be in required. The contractor will provide a detailed excavation and blasting plan defining excavation methods, lift height, drilling pattern and explosive use for approval before commencing work.

Excavation is expected to proceed in a series of shallow lifts following the normal sequence of drill, blast and excavate. If necessary for support, rock bolts will be installed in the vertical walls as excavation advances. A crane will lift equipment in and out of the shaft excavation and hoist broken rock as required. Excavated material will be hauled to the spoil disposal area

It is expected that the complete wye branch steel liner will be too large to ship in one piece from the fabrication plant to the site. Pieces will be received at the laydown area and assembled into one piece ready for installation in the shaft.

4. Powerhouse

During the pre-shutdown phase, work in the powerhouse will be coordinated with plant operations, which may require an intermittent work schedule.

Work will comprise installation of the hydraulic power equipment and accumulators at El. 304 inside the powerhouse and relocation of utilities where the turbine shutoff valve is to be installed. Enlargement of hatch openings to allow installation of the turbine shutoff valve will be delayed until shortly before plant shutdown as this work will open the powerhouse to the weather and create a potential hazard which must be mitigated.

Turbine shutoff valve components will be received and stored on site.

6.1.3. PHASE II – SHUTDOWN

Time is of the essence while the powerplant is shut down. The timing of the shutdown is controlled by plant operational constraints and construction work must be fitted into the available time. Most of the work scheduled during this period will be performed in confined areas restricting the number of workers who can work effectively. Construction work may proceed on a round-the-clock basis with double shifting and overtime as required to meet scheduled milestones.

1. Penstock

After the plant is shutdown the intake gate will be closed and the penstock tunnel dewatered. The inside of the penstock will be inspected and the contractor will take measures to control and divert water running down the penstock invert so that it does not interfere with performance of work. The Specifications will call for the Contractor to devise the diversion facilities to handle a flow of up to 300 gallons per minute.

2. Wye Branch

Phase II of the wye branch access shaft excavation will be completed after the penstock is dewatered. This phase of the work requires excavation of rock and concrete from around the perimeter of the existing penstock and the cutting and removal of a 25-foot long section of 14-foot diameter penstock, which is surrounded by an annulus of concrete of variable thickness. The exact dimensions of the excavation will be determined by the contractor provided that he must allow sufficient space to set the wye branch and embed it in concrete as shown on the drawings. The presence of the penstock will cause the work to be slow and care will be required to avoid damage to the penstock that will remain in place. After excavation is complete and the section of penstock removed, the ends of the remaining penstock will be prepared ready to accept the new wye branch.

Installation work will commence with setting the steel transition section to the bypass followed by placement of the wye branch. The complete wye assembly will weigh about 50 tons and it is expected that it will be placed in one piece. Following installation and testing, the wye branch and transition section will be encased in concrete and the access shaft will be backfilled with selected material compacted in layers. A small bulldozer and compactor will work in the shaft to compact material.

Inside the penstock, internal bracing will be removed, the acoustic flow meter components installed and the surfaces of the steel liner cleaned and painted.

3. Powerhouse

Following shutdown of the powerhouse, all remaining utility pipe and wiring will be removed from the work area surrounding the location of the new shutoff valve. After the penstock is drained, the penstock access manhole will be opened, the mechanical coupling inside the powerhouse removed and temporary lights and ventilating fans installed inside the penstock.

The perimeter of the powerhouse concrete wall to be demolished and the section of penstock to be removed will be cut by wire saw, or other approved means. The exact depth of concrete to be removed will be determined from dimensions and details provided by the valve manufacturer. Concrete and steel will be removed as required and debris will be hoisted to waste through the powerhouse hatch. The end of the remaining steel penstock liner will be prepared ready to accept the new steel spool section to be installed.

After preparatory work is complete the new steel penstock spool sections and turbine shutoff valve will be installed and aligned followed by reconstruction of the concrete wall of the powerhouse. The valve bypass and utility piping, electrical and control systems will then be installed. Reconstruction of the hatchways will proceed as convenient.

4. Testing and Commissioning

Prior to watering up the penstock all powerplant and bypass systems will be dry tested in the presence of manufacturer's and Agency's representatives

6.1.4. PHASE III – POST SHUTDOWN

After dry testing is complete the penstock will be rewatered and all systems tested under operating conditions prior to putting the plant back online. Powerhouse hatch enlargements will be restored to original dimensions and security fencing rebuilt.

Temporary facilities and roads will be removed and the area cleaned and restored. At the laydown areas, contractor's equipment will be removed and the areas dressed to provide useful permanent storage space.

6.2 Construction Schedule

6.2.1. INTRODUCTION

Preliminary schedules for the construction of the complete project and for the shutdown period are depicted on Figure 6-1 and Figure 6-2 respectively. Because of the lead-time required for valve design and manufacture, there is more than adequate time to perform the pre-shutdown phase of the work allowing considerable flexibility in planning this phase of the work. The preliminary schedules are based on delaying the start of work to minimize the overall duration that the contractor is on site, however actual contractor schedules may vary from this concept.

The contract duration from Notice to Proceed until all permanent work is complete and the plant is back on line is scheduled to be 18 months. Additional time of about 4 months prior to contract notice to proceed is required to solicit bids and select a contractor. After permanent work is complete on site several weeks should be allowed to finalize contract details and complete punch list items.

Estimated delivery time for the valves is 11 months comprising 3 months for approval of drawings and 8 months for manufacture and delivery to the site after drawing approval. A contingency of two months has been added to provide for variations in actual low bid delivery guarantees. To schedule valve installation commencing in September, construction bids should be solicited not later than March 1st. of the previous calendar year as summarized in the following table:

Solicit Bids and Award Contract	4
Submit and Approve Shop Drawings	3
Manufacture and Deliver Valves	8
Contingency	2
Store on Site	1
Total Lead Time	18 months

6.2.2. SCHEDULE CONSIDERATIONS

To protect against frivolous claims project specifications provide liberal durations for submittal and approval of required documentation and samples. The schedule in the first few weeks of the program is predicated on all parties expediting these submittals so they do not delay progress of the work.

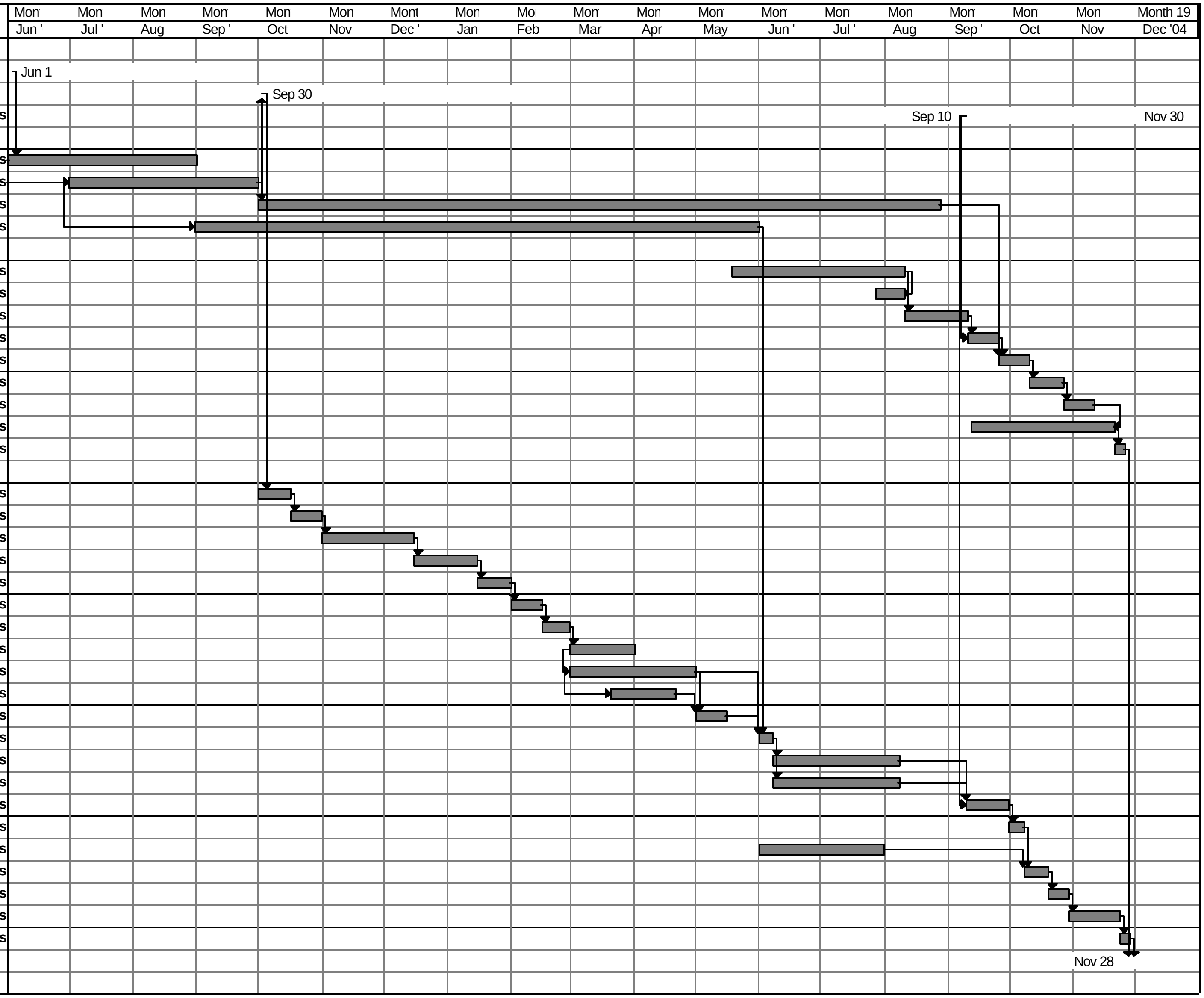
Delivery of large valves and steel tunnel liners are expected to be the activities constraining completion of the project.

The schedule does not include lost time due to flooding or spillway discharges.

NARROWS 2 HYDRO POWER PLANT - FLOW BYPASS SYSTEM
PRELIMINARY CONSTRUCTION SCHEDULE

FIGURE 6-1

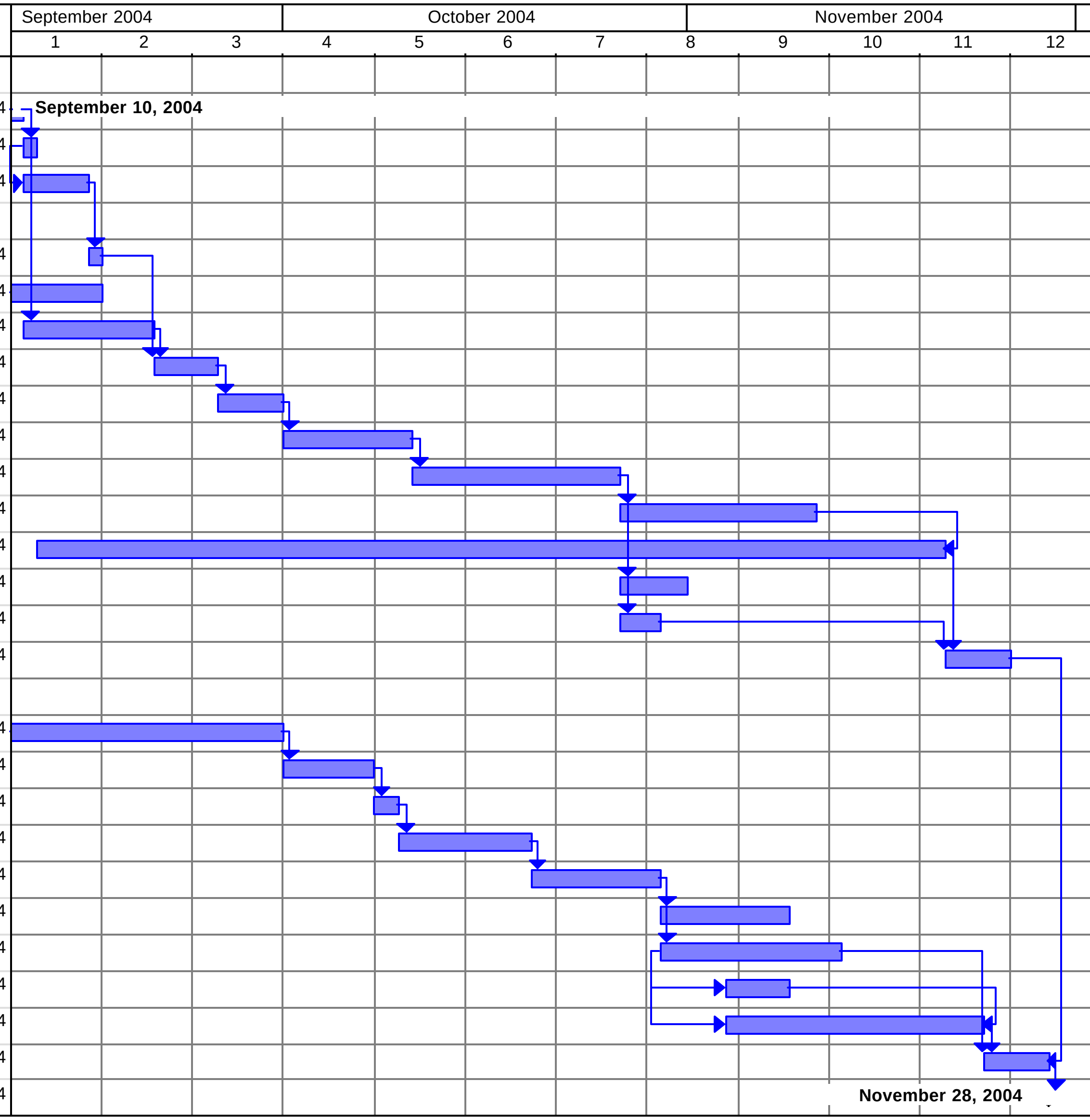
ID	Task Name	Duration
1	**CONTRACT ADMINISTRATION**	
2	Notice to Proceed - Equipment	
3	Notice to Proceed - Construction	
4	Plant Shutdown	82 days
5	**VALVE MANUFACTURE**	
6	Submittals	92 days
7	Review and Approvals	92 days
8	Man./Del. Turbine Shutoff Valve	332 days
9	Man./Del. Bypass Valves	275 days
10	**POWERHOUSE**	
11	Pre-Shutdown Work	84 days
12	Modify Access Hatches	14 days
13	Float	31 days
14	Remove Penstock Section	15 days
15	Set Turbine Shutoff Valve	15 days
16	Align/Weld Turbine Shutoff Valve	16 days
17	Install Bypass	15 days
18	Mech./Elec./Controls	70 days
19	Testing	5 days
20	**BYPASS**	
21	Mobilize	16 days
22	Excavate Bench @ El. 348	15 days
23	Excavate for Bypass Structure	45 days
24	Tunnel & Channel Excavation	31 days
25	Structure Concrete - Base Slab	16 days
26	Install Tunnel & Hood Liners	15 days
27	Concrete Tunnel Liner	14 days
28	Drill & Grout Tunnel Liner	31 days
29	Structure Concrete - Walls/Roof	61 days
30	Assemble Bridge	31 days
31	Erect Bridge,Ladders, Platforms	15 days
32	Set Bypass Valves	7 days
33	Complete/Dry Test Valves	61 days
34	Excavate Wye Branch Stage I	61 days
35	Excavate Wye Branch Stage II	21 days
36	Remove Penstock Section	7 days
37	Assemble/Weld/Hydro Wye Branch	61 days
38	Set/Weld Wye Branch	12 days
39	Embed Wye Branch	10 days
40	Grout, Drains, Metering Equip	25 days
41	Clean, Test & Commission	5 days
42	Plant Operational	
43		



NARROWS 2 HYDRO POWER PLANT - FLOW BYPASS SYSTEM
PRELIMINARY CONSTRUCTION SCHEDULE
PLANT SHUTDOWN (CALENDAR DAYS)

FIGURE 6-2

ID	Task Name	Duration	Start
1	**PENSTOCK**		
2	Close Gate and Dewater Tunnel	1 day	Fri 9/10/04
3	Open Manhole and Instal Ventilation	1 day	Sat 9/11/04
4	Control Tunnel Seepage	5 days	Sat 9/11/04
5	**POWERHOUSE**		
6	Remove Penstock Coupling	1 day	Thu 9/16/04
7	Remove Mech/Elec Utilities	7 days	Fri 9/10/04
8	Demolish Wall in Powerhouse	10 days	Sat 9/11/04
9	Cut and Remove Penstock Section	5 days	Tue 9/21/04
10	Install New Spool and Flange	5 days	Sun 9/26/04
11	Form/Pour New North Wall	10 days	Fri 10/1/04
12	Align/Weld Turbine Shutoff Valve	16 days	Mon 10/11/04
13	Instal Bypass	15 days	Wed 10/27/04
14	Instal Utilities and Controls	70 days	Sun 9/12/04
15	Grout Valve Supports	5 days	Wed 10/27/04
16	Instal Coupling	3 days	Wed 10/27/04
17	Dry Testing	5 days	Sun 11/21/04
18	**BYPASS**		
19	Complete Access Shaft Excavation	21 days	Fri 9/10/04
20	Cut and Remove Penstock Section	7 days	Fri 10/1/04
21	Instal Bypass Transition	2 days	Fri 10/8/04
22	Instal Wye Branch and Weld	10 days	Sun 10/10/04
23	Concrete Embedment	10 days	Wed 10/20/04
24	Backfill Access Shaft	10 days	Sat 10/30/04
25	Grouting and Drainage	14 days	Sat 10/30/04
26	Instal Acoustic Flow Meter	5 days	Thu 11/4/04
27	Remove Spiders, Clean and Paint Liner	20 days	Thu 11/4/04
28	Clean, Test, Commission	5 days	Wed 11/24/04
29	Plant Operational		Sun 11/28/04



7. ENGINEER'S COST ESTIMATE

7.1 Introduction

The Engineers cost estimate for performing the construction work is presented in Table 7-1. The estimates includes the cost of all labor, materials, construction equipment and services required to construct and commission the facilities as described in the contract documents including contractor's overhead and profit.

The estimate does not include costs attributable to the following factors:

- Escalation
- Lost power generation
- Licensing
- Contingency

7.2 Estimate Basis

7.2.1. BASE DATE

The effective base date for the cost estimate is September 30 2002 and all estimated costs are applicable to that date assuming a contract will be awarded in the second quarter of 2003 and all permanent work will be complete by December 2004. Escalation to some future date may be estimated at 5% per year.

7.2.2. MOBILIZATION

Mobilization shown in the estimate is a provision for costs incurred by the contractor in establishing temporary services and facilities at the project site.

7.2.3. QUANTITIES

Quantities used in the estimates have been calculated using dimensions shown on the design drawings or scaled from those drawings.

7.2.4. UNIT PRICES

Unit prices shown in the estimates include allowances for performing all the activities normally required to execute the work shown on the drawings, including preparatory work such as grading and subgrade preparation, supply of miscellaneous ancillary materials and cleanup of the project site when work is complete.

7.2.5. Labor Rates

Labor rates used in preparing the estimates are those published in the General Prevailing Wage Determination for Northern California counties for the second half of 2002 pursuant to the California Labor Code. Except as noted, estimates are based on the work being performed in normal working hours without regularly scheduled overtime or weekend work. Labor estimates include an allowance of 3% for occasional overtime to finish and cure concrete and similar unplanned events.

7.2.6. Permanent Equipment

Estimated costs of valves and other major equipment are based on preliminary informal vendor quotations. Market conditions at the time of bidding may result in actual prices that differ from these estimates. Installation estimates include the cost of transportation from the manufacturer's plant and the provision of suitable storage of components at the project site in addition to the cost of labor and equipment for installation. The estimate also includes provision for the cost of manufacturers representatives during installation and startup.

7.2.7. Contingency

The Engineers Estimate is a forecast of expected bid prices from contractors and does not include any Agency’s contingency.

The project budget should include a contingency allowance to provide for the cost of schedule changes, work that is not currently foreseen and other Agency generated expense that may arise in the course of construction. Considering the tight shutdown schedule and the fact that the project is located in an active river valley subject to fluctuating stream flow, a contingency allowance of 10% is suggested.

Table 7-1
Narrows 2 Powerplant Flow Bypass System
Engineer's Cost Estimate

Item No.	Spec. Ref.	Description	Unit	Approx. Quantity	Unit Price	Amount
DIVISION 1 - GENERAL REQUIREMENTS						
1	01500	Developing Temporary Access Roads including Removal upon Project Completion	LS	1	62,300	$ 62,300
2	01505	Mobilization	LS	1	194,300	194,300
3	01560	Air and Water Pollution Control	LS	1	44,400	44,400
DIVISION 2 - SITEWORK						
4	02050	Demolition and Removal	LS	1	45,400	45,400
5	02200	Excavation in Open Cut	CY	2000	92.00	184,000
6	02200	Excavation for Access Shaft including El. 348 Bench	LS	1	785,300	785,300
7	02200	Shaft Backfill	LS	1	33,300	33,300
8	02210	Presplitting	SY	300	35.00	10,500
9	02210	Furnishing Blast Monitoring Equipment	LS	1	20,000	20,000
10	02247	Drilling Holes for Consolidation Grouting	LF	360	16.60	7056
11	02247	Cement for Consolidation Grout	Bags	360	15.40	5,544
12	02310	Tunnel Excavation	LF	43	3,900	167,700
13	02390	Furnishing & Installing Resin-Anchored Rock Bolts	LF	650	40.00	26,000
DIVISION 3 - CONCRETE						
14	03200	Furnishing and Installing Steel Reinforcing Bars	LB	120000	1.13	135,600
15	03200	Furnishing and Installing Resin Dowel Bars in Existing Concrete	EA	170	100.00	17,000
16	03200	Furnishing & Installing Welded Wire Fabric	SF	4500	5.10	22,950
17	03254	Furnishing & Installing 9 inch ribbed PVC Waterstop	LF	400	20.60	8,240
18	03254	Furnishing and Installing Retrofit PVC Waterstop	LF	90	100.00	9,000
19	03300	Cast-in-Place Concrete in Bypass Valve Structure	CY	1000	500.00	500,000
20	03300	Cast-in-Place Concrete in Powerhouse	CY	20	700.00	14,000
21	03300	Cast-in-Place Concrete Encasement for Steel Tunnel lining	LF	43	1100.00	47,300
22	03300	Cast-in-Place Concrete Encasement of Wye Branch	LS	1	174,000	174,000
23	03361	Shotcrete	CY	30	800.00	24,000

Table 7-1

Narrows 2 Powerplant Flow Bypass System
Engineer's Cost Estimate
Sheet 2 of 3

Item No.	Spec. Ref.	Description	Unit	Approx. Quantity	Unit Price	Amount
		DIVISION 5 - METALS				
24	05565	Fabrication and Installation of 96 inch Diameter Steel Tunnel Liner	LF	31	2,300	$ 71,300
25	05565	Fabrication and Installation of 168 inch to 168 inch and 138 inch Wye Branch.	LS	1	358,300	358,300
26	05565	Fabrication and Installation of 138 inch by 96 inch Diameter Transition.	LS	1	43,900	43,900
27	05565	Fabrication and Installation of 96 inch by 78 inch Diameter Transition.	LS	1	24,200	24,200
28	05565	Fabrication and Installation of 18 feet Diameter Steel Hood Liner.	LS	1	144,100	144,100
29	05600	Furnishing and Installing Structural Steel for Access Bridge	LB	10,500	4.10	43,050
30	05600	Furnishing and Installing Deck Grating for Access Bridge	LB	7400	5.10	37,740
31	05600	Furnishing and Installing Steel Plates, Bars, Rods, Shapes, Bolts and Grating for Ladders,Platforms and Other Miscellaneous Appplications	LB	5000	7.20	36,000
32	05600	Furnishing and Installing Pipe Handrail	LB	2100	18.50	38,850
33	05600	Furnishing and installing 2.5 ft. x 8.5 ft. Floor Door - H20 Loading	EA	1	10,100	10,100
34	05600	Furnishing and Installing 2.5 ft. x 3 ft. Roof Scuttle for Access Ladder	EA	1	3,700	3,700
35	05600	Furnishing and Installing Permanent Chain Link Fencing	LF	50	62.00	3,100
		DIVISION 15 - MECHANICAL				
36	15010	Furnishing Installing and Testing Miscellaneous Mechanical Items	LS	1	150,300	150,300
37	15020	Design Furnishing and Installing Hydraulic System Components	LS	1	205,900	205,900
38	15030	Designing, Manufacturing, Installing and Testing 168-inch Diameter Turbine Shutoff Valve, Butterfly Type, and all Auxiliaries complete.	EA	1	696,600	696,600

Table 7-1
Narrows 2 Powerplant Flow Bypass System
Engineer's Cost Estimate
Sheet 3 of 3

Item No.	Spec. Ref.	Description	Unit	Approx. Quantity	Unit Price	Amount
39	15040	Designing, Manufacturing, Delivery, Installing and Testing 78-inch Diameter Bypass Valve, Fixed Cone Type, and all Auxiliaries complete.	EA	1	294,000	294,000
40	15050	Designing, Manufacturing, Delivery, Installing and Testing 78-inch Diameter Bonneted Knife Gate Valve, and all Auxiliaries complete.	EA	1	189,400	189,400
		DIVISION 16 - ELECTRICAL				
41	16110	Furnishing and Installing Conduit System	LS	1	49,400	$ 49,400
42	16120	Furnishing and Installing Wire and Cable	LS	1	20,600	20,000
43	16135	Furnishing and Installing Basic Electrical Equipment	LS	1	8,400	8,400
44	16390	Furnishing and Installing Grounding System	LS	1	7,800	7,800
45	16500	Furnishing and Installing Lighting Fixtures, Receptacles and Outlets	LS	1	3,600	3,600
		TOTAL BID PRICE				**$4,978,230**

8. DELIVERABLES

8.1 Specifications

The Construction Specifications Institute (CSI) format is used for the specifications. Each division of work (e.g. General Requirements, Site Work and Concrete) is subdivided into sections to include project needs. Each section is further subdivided into the following three parts:

- Part 1: "General", includes work scope, standards, definitions, and required submittals.
- Part 2: “Products", specifies construction material requirements.
- Part 3: "Execution", specifies work performance requirements and quality control.
- Part 4 – “Measurement and Payment”, specifies the method of quantity measurement and the basis for payment.

The following specifications are included in the bid documents:

DIVISION 1 - GENERAL REQUIREMENTS

01010 Summary of Work
01050 Layout of Work and Surveys
01150 Measurement and Payment
01300 Submittals
01500 Temporary Facilities
01505 Mobilization and Demobilization
01560 Air and Water Pollution Control
01700 Project Closeout

DIVISION 2 - SITEWORK

02050 Demolition and Removal
02180 Water Diversion and Control
02200 Earthwork
02210 Blasting
02247 Pressure Grouting
02292 Spoil Disposal
02310 Tunnel Excavation
02390 Rock Reinforcement

DIVISION 3 - CONCRETE

03100 Concrete Formwork
03200 Concrete Reinforcement

03254 Concrete Joints, Waterstops, and Drain Pipe
03300 Cast-in-Place Concrete
03361 Shotcrete

DIVISION 5 - METALS

05565 Steel Liners and Wye Branch
05600 Structural Steel and Miscellaneous Metal
05605 Chain Link Fencing

DIVISION 15 - MECHANICAL

15010 Miscellaneous Mechanical Items
15020 Hydraulic System Components
15030 Turbine Shutoff Valve
15040 Bypass Valve
15050 Guard Valve

DIVISION 16 - ELECTRICAL

16110 Conduit Systems
16120 Wire and Cable
16135 Miscellaneous Electrical Equipment
16390 Grounding
16500 Lighting
16975 Testing and Start-up

8.2 Drawings

The following is a list of drawings included in the bid document packages:

Drawing No.	**Title**
General Drawings	
N2-10-251	Title Sheet and Drawing Index
N2-10-252	Location Map
N2-10-253	Project Vicinity Map
N2-10-254	General Arrangement Site Plan
N2-10-255	Construction Access
Bypass Tunnel Drawings	
N2-31-551	Bypass Tunnel & Steel Liner - Plan, Profile & Sections
N2-31-552	Wye Branch – Plan, Sections & Details

Powerhouse Modification Drawings	
N2-41-251	Concrete Removal - Plans, Sections & Details
N2-41-252	Concrete Outline & Reinf. - Plans, Sections & Details
N2-42-251	Turbine Shutoff Valve – General Arrangement - Plans and Sections
Bypass Valve Structure Drawings - Civil	
N2-51-151	Excavation - Plan
N2-51-152	Excavation - Sections
N2-51-251	Concrete Outline - Plans & Sections
N2-51-252	Concrete Outline - Sections and Details
N2-51-351	Reinforcement - Typical Details and General Notes
N2-51-352	Reinforcement - Plans and Sections
N2-51-353	Reinforcement - Sections
N2-51-354	Reinforcement - Sections and Details
N2-53-851	Access Bridge - Plan, Sections & Details
N2-53-852	Miscellaneous Metal - Ladders, Platforms & Guard Rail
N2-53-853	Deflector Hood – Sections and Details
Mechanical Drawings	
N2-54-301	Bypass Valve Structure – Equipment Arrangement – Sh. 1
N2-54-302	Bypass Valve Structure – Equipment Arrangement – Sh. 2
N2-55-301	Hydraulic Control Schematic
N2-55-302	Hydraulic Power Unit – General Arrangement
Electrical Drawings	
N2-57-301	Electrical – Piping & Instrumentation Diagram
N2-57-302	Elementary Diagram – Hydraulic and TSV Control
N2-57-303	Elementary Diagram – Bypass Valves Control and PLC Outputs
N2-57-304	Powerplant – Conduit Plans, Sections & Details
N2-57-305	Bypass Valve Structure – Conduit and Lighting – Plans, Sections and Details

9. REFERENCES

1. California State Water Resources Control Board, ***Water Right Decision 1644 in the Matter of Fishery Resource and Water Rights Issue of the Lower Yuba River***, Adopted March 1, 2001.

2. International Engineering Company, Inc., ***Yuba River Development, Specification 65-674, Volume II – Technical Specifications***, May 1966.

3. International Engineering Company, Inc., ***Yuba River Development, New Narrows Power Project – As Built Drawings,*** June 1970.

4. Morrison Knudsen Corporation, ***Narrows 2 Hydro Power Plant – Report on Flow Bypass System Study***, October 1999.

Appendix A

Extract from California State Water Resources Control Board Order for Interim and Long-Term Flow Requirements

After 2006

Long-Term Instream Flow Requirments

Periods	Wet, Above Normal & Below Normal Years (cfs)		Dry Years (cfs)		Critical Years (cfs)		Extreme Critical Years* (cfs)	
	Smartville Gage	Marysville Gage	Smartville Gage	Marysville Gage	Smartville Gage	Marysville Gage	Smartville Gage	Marysville Gage
Sept. 15 - Oct 14	700	250	500	250	400	250	400	250
Oct 15 - Apr 20	700	500	600	400	600	400	600	400
Apr 21 - Apr 30	–	1,000	–	1,000	–	1,000	–	500
May 1 - May 31	–	1,500	–	1,500	–	1,100	–	500
Jun 1	–	1,050	–	1,050	–	800	–	500
Jun 2	–	800	–	800	–	800	–	500
Jun 3 - Jun 30	–	800	–	800	–	800	–	500
Jul 1	–	560	–	560	–	560	–	500
Jul 2	–	390	–	390	–	390	–	390
Jul 3 - Sept. 14	–	250	–	250	–	250	–	250

* "Extreme Critical" year classification is defined as: Equal to or less than 540 TAF on the Yuba River Index scale.

b. For purposes of this order, wet, above normal, below normal, dry and critical water year types in the table above are as defined in the Yuba River Index. (See Appendix 1.) Extreme critical water years are defined as years when the Yuba River Index is predicted to be less than 540 thousand acre-feet. Determination of water year classifications shall be made on April 1 of each year, in accordance with the forecast of unimpaired flow of the Yuba River at Smartville published in California Department of Water Resources Bulletin 120. The year type for the preceding water year shall remain in effect until April 1 when the current year forecast is available.

c. In order to avoid potential aggravation of the electrical energy crisis in California present in early 2001, the flows specified above in part "a." of this term shall come into effect on April 21, 2006. In the interim period, streamflow shall be maintained at or above the flows specified in the following table as measured at the USGS gaging installations at Marysville and Smartville.

Interim Instream Flow Requirements 2001 to 2006

Period	Wet & Above Normal Years (cfs)		Below Normal Years (cfs)		Dry Years (cfs)	
	Smartville Gage	Marysville Gage	Smartville Gage	Marysville Gage	Smartville Gage	Marysville Gage
Sep 15-Oct 14	700	250	550	250	500	250
Oct 15-Apr 20	700	500	700	500	600	400
Apr 21-Apr 30	--	1,000	--	900	--	400
May 1-May 31	--	1,500	--	1,500	--	500
Jun 1	--	1,050	--	1,050	--	400
Jun 2-Jun 30	--	800	--	800	--	400
Jul 1	--	560	--	560	--	280
Jul 2	--	390	--	390	--	250
Jul 3-Sep 14	--	250	--	250	--	250
Period	Critical Years (cfs)		2001 to April 2002 is a critical year			
	Smartville Gage	Marysville Gage				
Sep 15-Oct 1	400	150				
Oct 1-Oct 14	400	250				
Oct 15-Apr 20	600	400				
Apr 21	--	280				
Apr 22-Apr 30	--	270				
May 1-May 31	--	270				
Jun 1-July 2	--	(See Note)				
July 3-Sep 14	--	100				

Table Note: The interim instream flow requirements for June 1-30 of critical years shall be 245 cfs pursuant to the provisions of the agreement between Yuba County Water Agency and the Department of Fish and Game dated September 2, 1965, except if a lower flow is allowed pursuant to the provisions of the 1965 agreement. The minimum flow on July 1 shall be 70 percent of the flow on June 30, and the minimum flow on July 2 shall be 70 percent of the flow on July 1.

2. To minimize water temperature impacts on anadromous fish and other public trust resources in the lower Yuba River, permittee shall comply with the following terms and conditions:

   a. Permittee shall diligently pursue development of the Narrows II Powerhouse Intake Extension Project at Englebright Dam, in coordination with the Department of Fish and Game, the United States Fish and Wildlife Service and the National Marine Fisheries Service. Permittee shall submit proposals for project funding and prepare all appropriate

CEQA documentation for project development in a timely manner. Permittee shall submit proposals for project funding and prepare all appropriate CEQA documentation for project development in a timely manner. Permitttee shall submit a report to the Chief of the Division of Water Rights on the status of its application for funding and the progress of project development every six months from the date of this Order through the completion of project construction.

b. Permittee shall coordinate operation of available temperature control devices to minimize temperature impacts on anadromous fishery resources in the lower Yuba River. Permittee shall consult with the Temperature Advisory Committee (composed of representatives from the SWRCB, the Department of Fish and Game, the United States Fish and Wildlife Service, the National Marine Fisheries Service, the California Sportfishing Protection Alliance and the South Yuba River Citizens League) on a regular basis during the temperature control season (May through October). Permittee shall monitor water temperature effects of project operations and report to the Advisory Committee on a regular basis. Permittee shall discuss with the Committee current operations for temperature control and variances from the temperatures needed to provide suitable habitat for anadromous fish. Permittee shall make changes to project operations for temperature control as recommended by the Temperature Advisory Committee on a real-time basis, unless Permittee informs the Chief of the Division of Water Rights within 14 days that the Committee recommendation is infeasible and explains the basis for that conclusion.

c. Prior to April 1 of each year, permittee shall prepare an annual operations plan for water temperature control in consultation with the Temperature Advisory Committee. The plan shall specify actions to be taken to maintain suitable water temperatures for anadromous fish in the subsequent May through October period. The plan shall be submitted to the Chief of the Division of Water Rights for approval by April 1 of each year, and shall describe proposed operations for the subsequent May through October period.

d. Permittee shall install and operate automated temperature monitoring equipment and record water temperatures on an hourly basis at the Smartville Gage, Daguerre Point Dam, and the Marysville Gage. Permittee shall prepare an annual monitoring report that summarizes the results of water temperature monitoring for the previous water year at the above-described locations and describes operations to minimize water temperature impacts on anadromous fish. The monitoring report covering the previous water year ending September 30 shall be submitted to the Chief of the Division of Water Rights by December 31 of each year.

e. The SWRCB retains continuing authority over this permit to establish water temperature requirements for the lower Yuba River for the protection of fishery resources following notice and opportunity for hearing.

December 2 Ramp up was an emergency per State Board

3. With the exception of emergencies, flood flows, bypasses of uncontrolled flows into Englebright Reservoir, uncontrolled spilling, or uncontrolled flows of tributary streams downstream of Englebright Dam, permittee shall make reasonable efforts to operate New Bullards Bar Reservoir and Englebright Reservoir to avoid fluctuations in the flow of the lower Yuba River downstream of Englebright Dam. Daily changes in project operations affecting releases or bypasses of flow from Englebright Dam shall be continuously measured at the USGS gage at Smartville and shall be made in accordance with the following conditions:

a. Project releases or bypasses that increase streamflow downstream of Englebright Dam shall not exceed a rate of change of more than 500 cfs per hour. Ramping Rate

b. Project releases or bypasses that reduce streamflow downstream of Englebright Dam shall be gradual and, over the course of any 24-hour period, shall not be reduced below 70 percent of the prior day's flow release or bypass flow.

Note

c. Once the daily project release or bypass level is achieved, daily fluctuations in the streamflow level downstream of Englebright Dam due to changes in project operations shall not vary up or down by more than 15 percent. Normal operations

d. During the period from September 15 to October 31, permittee shall not reduce the flow downstream of Englebright Dam to less than 55 percent of the maximum release or bypass level that has occurred during that September 15 to October 31 period or the minimum streamflow requirement that would otherwise apply, whichever is greater.

e. During the period from November 1 to March 31, permittee shall not reduce the flow downstream of Englebright Dam to less than the minimum streamflow release or bypass established under (d) above; or 65 percent of the maximum flow release or bypass that has occurred during that November 1 to March 31 period; or the minimum streamflow requirement that would otherwise apply, whichever is greater.

4. By July 1, 2001, permittee shall submit, for approval of the Chief of the Division of Water Rights, a report specifying the types and locations of gages that are capable of continuously measuring flows and temperatures required by the conditions of this permit. The report shall include a construction schedule for installation of any additional gages which may be needed to continuously measure flows and temperatures at the locations specified in this permit. No water shall be diverted under this permit unless permittee installs the devices in accordance with the plan and construction schedule as approved by the Chief of the Division of Water Rights. Permittee shall ensure that said devices are properly maintained.

5. Permittee shall maintain a continuous record of the daily instream flows at the Smartville and Marysville Gages sufficient to document compliance with the terms of this permit. Permittee shall also maintain hourly records of water temperatures at Marysville, Smartville and

Appendix B
Report – Geotechnical Conditions at the Narrows Bypass Site

Yuba County Water Agency

Geotechnical Conditions at the Narrows 2 Flow Bypass Site

Yuba County
California

March, 2004

Submitted By:

Christensen Associates Inc

Yuba County Water Agency
1402 D Street
Marysville, CA 95901

Geotechnical Conditions at the Narrows 2 Flow Bypass Site

Yuba County
California

March, 2004

Prepared by:
Dr. Douglas H. Hamilton R.G., C.E.G.

Christensen Associates Inc
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Geotechnical Conditions at the Narrows Bypass Site
Yuba County, California

OUTLINE

ILLUSTRATIONS

I. Introduction

The Narrows bypass involves construction of a facility that will make it possible to divert flow from the Narrows 2 penstock tunnel and discharge it directly to the Yuba River downstream from Englebright Dam. The bypass facility is required in order to maintain fish flow in the river when the Narrows 2 powerhouse is out of service and the dam is not spilling, since the dam has no bottom outlet works. The bypass structure will consist of three principal components; 1.) a pipeline connected into the Narrows 2 penstock tunnel, 2.) a valve structure, and 3.) a short discharge channel. The facility will be located in the lower part of the southeast-facing northwest wall of the Yuba River narrows, about 30 feet upstream from the Narrows 2 powerhouse. Access for construction of the pipeline connection to the existing Narrows penstock will be in a new 35 feet diameter, 65 feet deep circular shaft. The upstream part of the pipeline will be in the bottom of this shaft and it will connect to the bypass valve structure via a 40 feet long tunnel. The surface space for construction of the shaft will be created by making a semi-circular cut extending into the lower part of the existing cut slope behind the roof deck of the Narrows powerhouse. The excavations required for the bypass project will therefore consist of the following:

- Semi-circular ¼:1 cut slope, 45 feet wide at its base and about 45 feet high
- Circular access shaft, 35 feet in diameter and 65 feet deep.
- Circular tunnel between the access shaft and the bypass valve structure, 40 feet long and 8 feet in diameter
- Bypass valve structure excavation 47 feet long, 27 feet wide and a maximum of 30 deep.
- Discharge channel 33 feet long, 18 feet wide and a maximum of 20 feet deep.

Most of the excavation for all components of the bypass facility will be in hard rock. The upper parts of the valve structure and discharge channel excavations, however, will extend through the boulder field located along the river margin upstream from the Narrows powerhouse.

The geologic conditions described and discussed in this report were observed, photographed and mapped from surface exposures during visits to the site on November 5, 2001 and January 17,

2002. A base topographic map and a stereoscopic pair of aerial photographs of the site were available for the January 17 visit when the mapping was done. The aerial photos were taken on December 4, 2001 and so represent current site conditions. Subsurface conditions were subsequently explored by drilling three diamond core borings in December, 2003. Logs and photographs of the core from these borings are presented in Appendix A to this report. The report was prepared under the terms of an agreement dated November 5, 2001 between Dr. Douglas H. Hamilton, C.E.G. and Christensen Associates Incorporated.

II. Site Geologic Setting

The Narrows bypass project is located within the Foothills metamorphic belt of the Sierra Nevada. The site bedrock is represented on the Chico Quadrangle of the State Geologic Map as belonging to the "dike complex" unit of the Smartville Complex of metavolcanic and metasedimentary rocks of Mesozoic age. The dike complex rocks are typically amphibolite grade metavolcanics that are resistant to erosion and tend to form high-standing topography, with drainage courses forming deep steep-walled gorges, such as the Yuba River narrows. Primary structures and contacts in the dike complex rocks tend to be fairly obscure and the strength of the rock mass is principally defined by secondary jointing and fracturing. An important feature influencing the rock conditions in the immediate vicinity of the bypass project is the pyrite mineralization present in some fracture zones as well as disseminated throughout the rock.. Oxidation and decomposition of this pyrite (FeS_2) to sulfuric acid and iron oxide has locally altered and weakened the fracture wall rock and created striking orange and yellow iron oxide staining in some areas.

The bypass site is located 3.7 miles (6.0 km) east of the Swain Ravine fault zone, which continues north to include the Cleveland Hill fault, source of the 1975 Oroville earthquakes. This fault zone is considered by DSOD to be capable of generating a M 6.5 earthquake.

III. Site Conditions

Following construction of the Narrows 2 power plant ending in 1970, the northwest wall of the Yuba River canyon downstream from Englebright Dam was partly covered with colluvium and, below the access road, with overcast spoils from the road excavation. Rock exposures were mainly in the road cuts and in riverfront bluffs below the road. The river channel was fairly clear, with a gravel terrace along its northwest side downstream from the powerhouse. The right abutment of the dam was set into a deep slot excavated in the bedrock of the northwest side of the canyon, about 300 feet upstream from the powerhouse. The plunge pool for the central spillway in the crest of the dam occupied the river channel at the downstream foot of the dam, and the channel continued downstream past the powerhouse without significant blockage or interruption.

This condition existed up to the flood of January 1997, when the river overtopped the entire dam and its abutments. The flood flow over and above the right abutment eroded about half the width of the ridge separating the dam right abutment slot and the powerhouse. The flow removed about 40 feet of fractured rock from the upper part of this ridge and thoroughly scoured the slope as far downstream as the upstream wall of the powerhouse. The large masses of rock plucked from the ridge were deposited in the river channel directly at the foot of the slope between the plunge pool and the powerhouse. The eroded area and boulder deposit are clearly visible in the aerial photo of the site, Figure 1. Views looking across the boulder deposit are shown on photo plates 3 and 4. The boulder deposit may be as much as 20 to 30 thick near the northwest canyon wall and consists of angular masses of hard rock up to about 20 feet across. In the area of the bypass valve structure and discharge channel, however, the boulder deposit appears to be mostly eight feet or less in thickness.

At the bypass valve structure site the flood – scoured lower canyon-wall slope is exposed between elevations 310-315, at the edge of the boulder deposit, and 370, at the upper limit of scour. The appearance of this scoured rock slope is shown on photo plate 4. Essentially all loose rock has been plucked from the slope and carried into the river. The exposed rock slope clearly exhibits all fractures that intersect the surface, with broken rock along large joints and fracture zones having been plucked to a depth of several feet.

Several principal joint and fracture sets are present in the rock at the bypass valve structure site, as plotted on the map presented on Figure 2. The first, set "A" is represented by four major joints that strike roughly normal (N20-30W) to the contour of the slope and dip steeply northeast. The second joint set, set "B", has controlled the form of the slope and is approximately represented by the topographic contours. Set "B" joints separate rock slabs several feet thick, the undercut lower edges of which form steps in the slope. It is not clear whether the set "B" slab joints are of tectonic or load relief (exfoliation) origin. In the former (tectonic) case they probably continue at depth while exfoliation joints are best developed near and parallel to the surface and die out within the rock mass at depth.

The third set consists of at least one fracture zone "C" that strikes roughly N-S and dips moderately west obliquely into the slope.

A fourth set, "D", consists of fairly regularly spaced cross joints that strike nearly east-west and dip steeply north. These joints divide the set "B" slabs into parallelogram-shaped blocks.

A fifth set "E", is not represented among the more prominent joints exposed in the bypass valve structure area, but forms the high wall along the west side of the major flood excavation on the north side of the ridge between the power house and the dam. Joints of this set strike roughly north-south and dip steeply east. The erosion high-wall joints align with a joint exposed in the cut slope above the northeast corner of the powerhouse and the set is probably continuous in the subsurface rock mass. The main "E" joint will be exposed in the east side of the new semi-circular slope cut for the access shaft and will probably be intersected by the connecting pipeline tunnel.

A zone of pyrite-mineralized fractures, "F", is also exposed in the cut slope behind the powerhouse approximately opposite the middle of the structure. This zone parallels the joints of set "A", and its strike also parallels the alignment of the lower reach of the penstock tunnel. The

"F" fracture zone will be exposed approximately down the center of the new semi circular cut slope and will extend across the access shaft, dipping steeply east. It may reach the cast side of the shaft in the vicinity of its junction with the connecting pipeline tunnel.

Several joints with strike parallel to that of set "A" but with opposite (southwest) dip were noted in the rock slope near the bypass valve structure. One of these dips 31 degrees toward the northeast side of the valve structure excavation and its downward projection would intersect the tunnel in the backwall of the excavation

IV. Diamond core drilling program

In December 2003 three vertical diamond core borings were made at the Narrows 2 bypass site. Two of the borings (01, 02) were drilled from the yard behind, and at the level of, the roof deck of the Narrows 2 Powerhouse. These borings were each drilled to a depth of about 70 feet, bottoming at an elevation approximately 6 feet below the bottom of the powerhouse floor level. Boring 01 was located about 15 feet south of the south side of the planned access shaft, and boring 02 was located on the shaft circumference directly over the centerline of the planned tunnel connecting the access shaft and the bypass valve structure. A third boring (03) was drilled in the boulder field where the bypass valve structure will be located. This boring was drilled along the structure center line near its downstream end. Boring 03 searched a depth of 21.1 feet and bottomed about 3 feet above the floor elevation of the structure.

The locations of the three borings are shown on Figure 2. Logs and photographs of the core are presented in Appendix A. It should be noted that the dark spots on the mostly light-grey colored core are from rain drops, not from the cored rock. Notes of "speckled" aspect of parts of the core given on the logs refer to light colored crystals that are not evident on the photographs. Variations in apparent hue of the core as photographed are mostly due to variations in core wetness.

The core was retrieved and boxed by the drillers, and was logged after drilling was completed. The core was not oriented as to azimuth so the specific strike of joints and fractures is not known. Most core breaks dip 45° or less, however and probably correspond to the southeast-dipping "B" joints seen in canyon wall outcrops. This aspect of similarity of dip is illustrated on Photo Plate P2, which shows both the outcrop jointing in the cut slope behind the power plant and a box of fractured core.

The lithology of the core from the three borings was quite uniform, consisting of light grey, very hard, very fine grained amphibolite (meta basaltic dike rock). RQD valves ranged from two 5' foot runs of 27% in boring 01, to several short runs with 90% to 100% in boring 03. Boring 01, located south of the access shaft, had the lowest RQD overall with 5 runs of less than 50% and 7 runs between 55% and a high of 81%.

Boring 02, over the shaft wall-tunnel junction, had 13.5 foot runs, with RQD ranging between 51% and 80%. Boring 03 had 7 runs ranging from 0.7 to 4.1 feet length, with RQD ranging from 59% to 100%.

A summary table and plot of core runs and RQD values for the 3 borings is included in Appendix A.

It is noteworthy that there is very little evidence of the steeply dipping but generally widely spaced joints and fractures that are prominent features in the canyon wall rock exposures, in the 3 core holes. We believe that this results from the 3 vertical borings having been made in blocks of rock between steeply dipping fractures, not from an absence of such fractures below outcrop levels.

V. Engineering geology considerations

It is planned that the bypass valve structure excavation be made to conform as nearly as practicable to the external dimensions of the structure. This will permit the concrete of the structure to be cast directly against the excavation walls, which will both permanently stabilize the excavated walls, and eliminate any opening that could be damaged by future flood flow. In order to most efficiently achieve this, it is anticipated that the excavation will have the form of a vertical rectangular shaft with a width of 27 feet and a length of 48 feet. The plan of the bypass features relative to topography and geology is shown on Figure 2. Profile cross sections through the valve structure excavation are shown on Figures 3 and 4. The rear wall will be 30 feet deep at its upstream centerline and will be altogether in rock. At about its longitudinal mid point the excavation will extend into the boulder deposit. We estimate that the 22-foot deep front wall (the valve structure-discharge channel interface), will be in boulders for its upper 5 to 8 feet, then in rock as projected on Figure 3.

The discharge channel will extend about 33 feet from the valve structure. We estimate that the lower section of this channel will be set partly into rock with boulder deposit upper side slopes. The channel slopes within the boulder deposit will average about 10 feet in height. Because of the possibility that the relatively high velocity flow of water in this channel could wash out the finer rock fragments and alluvium that forms the supporting matrix for the boulder-size fragments, consideration should be given to lining or otherwise protecting the boulder deposit slopes of the channel.

The bypass tunnel leading from the access shaft to the bypass valve structure will be entirely in rock. The depth of rock cover over the bypass tunnel crown will increase from about 17 feet at the tunnel-valve structure transition to about 48 feet at the access shaft tunnel junction. It appears that the bypass tunnel will intersect at least one of the major joint and fracture zones that are exposed at the surface, as well as, probably, numerous smaller breaks in the rock. Some of the fractures may be pyrite mineralized and subject to acid generation.

Excavation

Three general conditions of excavation will be required: 1) the benched and shaft sinking excavation of in-place rock for the access shaft and for most of the valve structure and the bottom part of the discharge channel; 2) excavation of the boulder deposit for the upper part of the valve structure and the discharge channel, 3) underground excavation of rock for the bypass tunnel and 4) benched surface excavation for the semicircular slope cut.

Rock fracture groundwater may exist within the hillside where the underground excavations will be made.

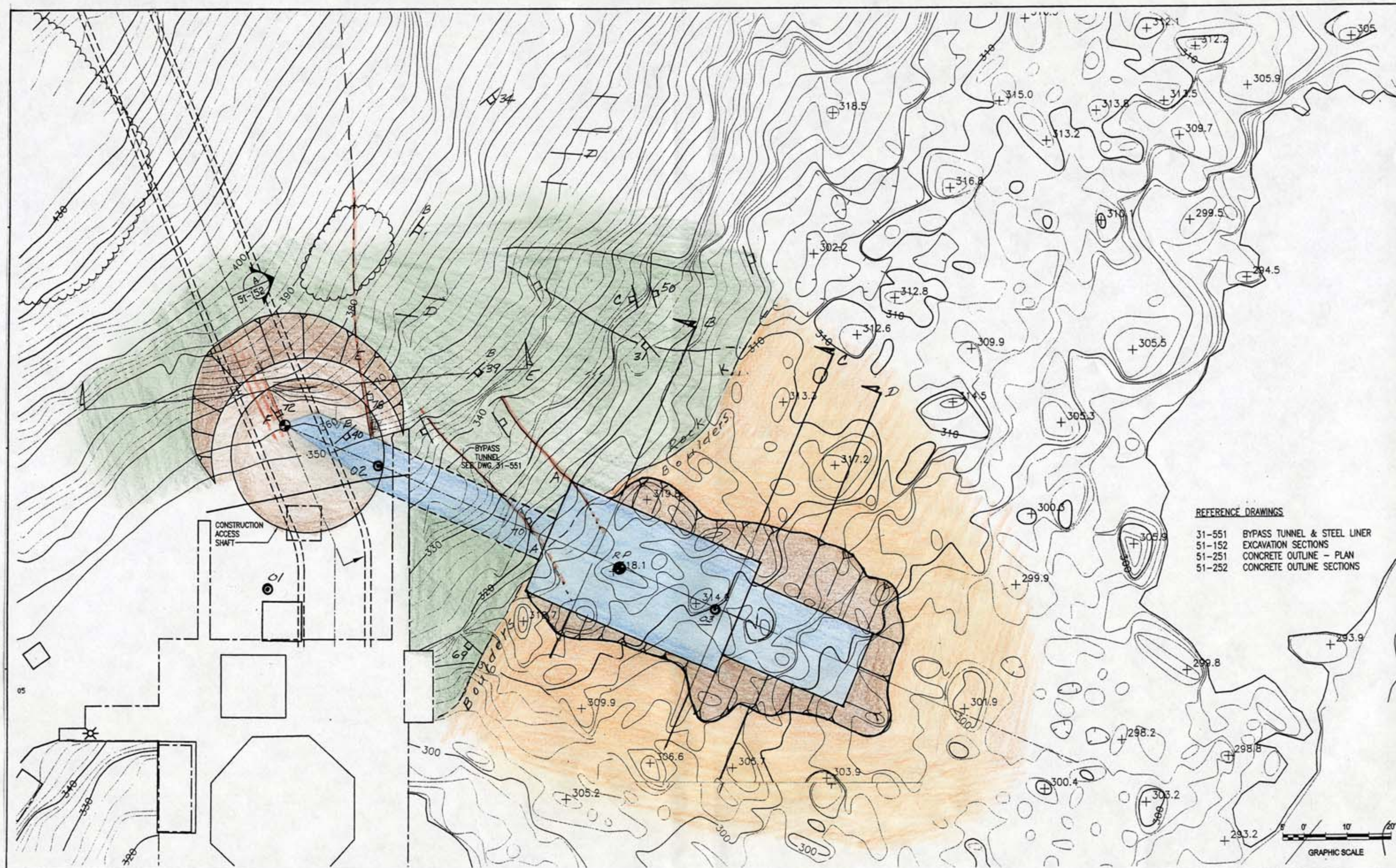
Excavation of the fractured but very hard in-place rock will require drilling and either or both, carefully controlled blasting or hydraulic splitting. Care will be required to limit vibratory motion affecting the adjacent powerhouse and penstock tunnel at the bottom of the access shaft.

Excavation of the boulder deposit for the valve structure and discharge channel will probably require breaking several large boulders to manageable size fragments by drilling and blasting.

Temporary reinforcement and containment of the ¼:1 to vertical walls of the semi-circular cut, access shaft, and valve structure excavations will be required in order to protect against fracture-bounded blocks dislodging and falling during construction. This will probably involve rock bolting and installation of chain link fencing, or similar measures. Some large wedges of rock above fractures dipping steeply into the excavation may have to be removed if inspection shows they cannot be readily secured. In any case the walls of the excavations should be carefully inspected and mapped as the excavations are deepened. Requirements for temporary support of the tunnel will be determined by conditions encountered during excavation but may included shotcreting, rock bolting, and possibly locally, steel sets if highly fractured zones are encountered.

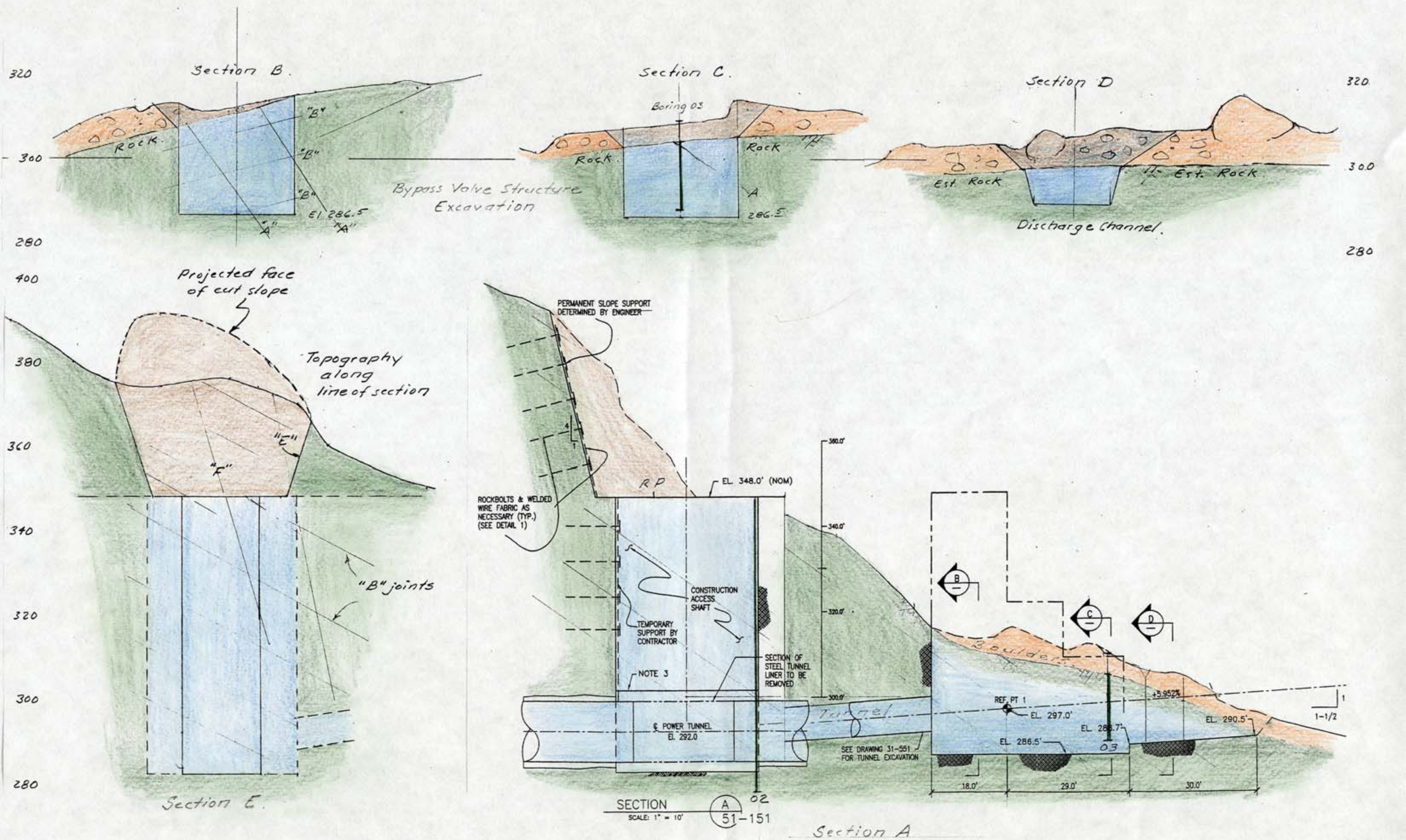
Narrows Bypass, Site and Vicinity Topography, and Project Layout

Figure 1.0



Narrows Bypass, Site Topography, Geology, and Project layout

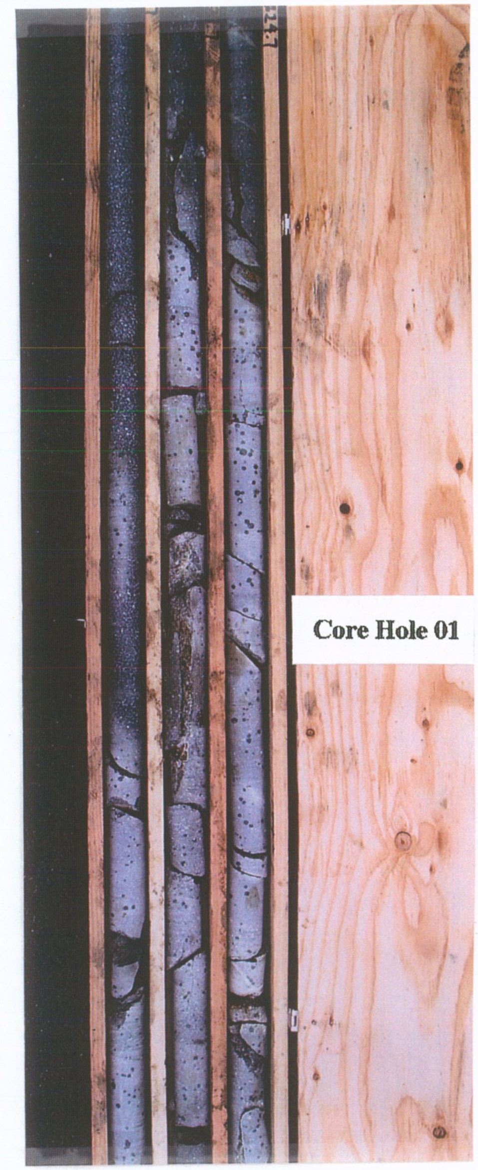
Figure 2.0



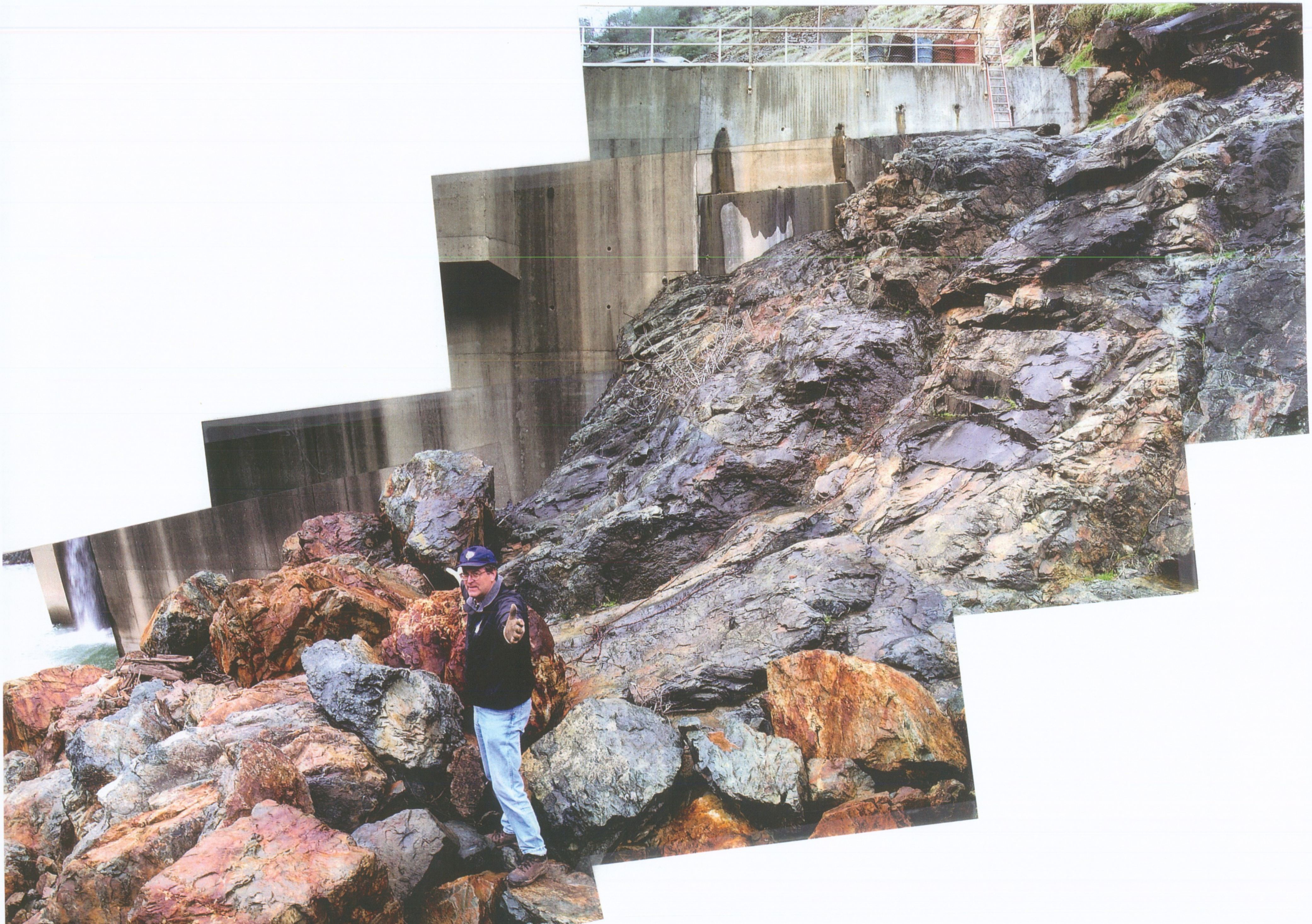
Narrows Bypass, Longitudinal Profile and Cross Sections

Figure 3.0

P1. Rock cut slope behind Narrows power house where new semi-circular cut will be excavated



P2. Rock cut slope showing prominent "B" jointing, with photograph of rock core showing similar joint fractures



P3. View along alignment of bypass tunnel. Steve Onken is demonstrating location of bypass valve structure back wall

P4. View showing lower rock slope and overlapping boulder deposit where bypass valve structure will be located

APPENDIX A

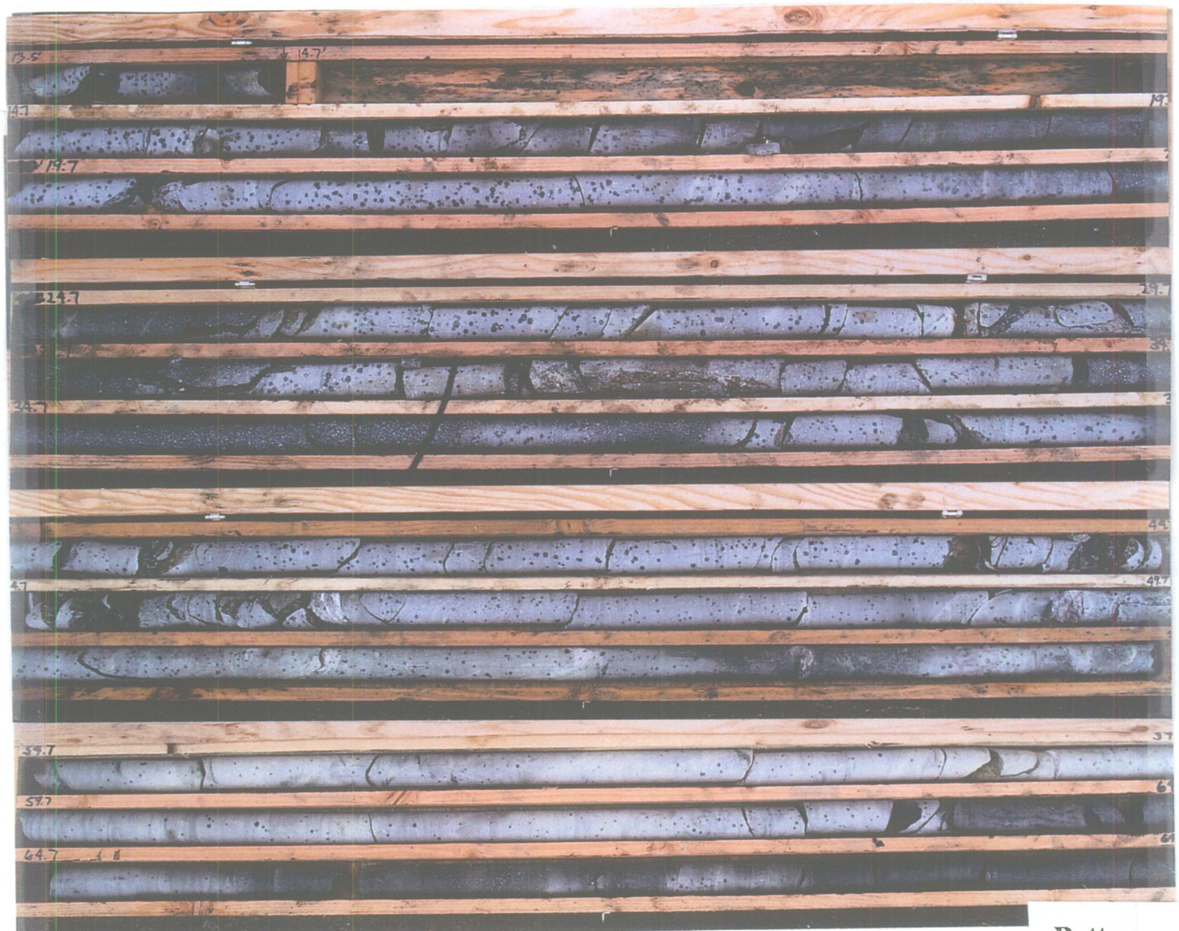
Core Boring Data

TABLE A

Summary of RQD Values
Borings 01, 02, and 03

Run No.	Interval	RQD
Boring 01		
1	13.5 – 14.7	55%
2	14.7 – 19.7	27%
3	19.7 – 24.7	78%
4	24.7 – 29.7	27%
5	29.7 – 34.7	38%
6	34.7 – 39.7	82%
7	39.7 – 44.7	48%
8	44.7 – 49.7	41%
9	49.7 – 54.7	74%
10	54.7 – 59.7	81%
11	59.7 – 64.7	72%
12	64.7 – 69.7	77%
Boring 02		
	4.9 – 7.8 = Concrete	
1	7.8 – 9.9	71%
2	9.9 – 14.9	80%
3	14.9 – 19.9	62%
4	19.9 – 24.9	68%
5	24.9 – 29.9	78%
6	29.9 – 34.9	72%
7	34.9 – 39.9	70%
8	39.9 – 44.9	57%
9	44.9 – 49.9	65%
10	49.9 – 54.9	51%
11	54.9 – 59.9	53%
12	59.9 – 64.9	75%
13	64.9 – 69.9	80%
Boring 03		
A	5.4 – 6.2	62%
B	6.2 – 6.9	100%
C	6.9 – 10.1	62%
D	10.1 – 12.0	84%
E	12.0 – 16.0	59%
F	16.0 – 17.0	90%
G	17.0 – 21.1	95%

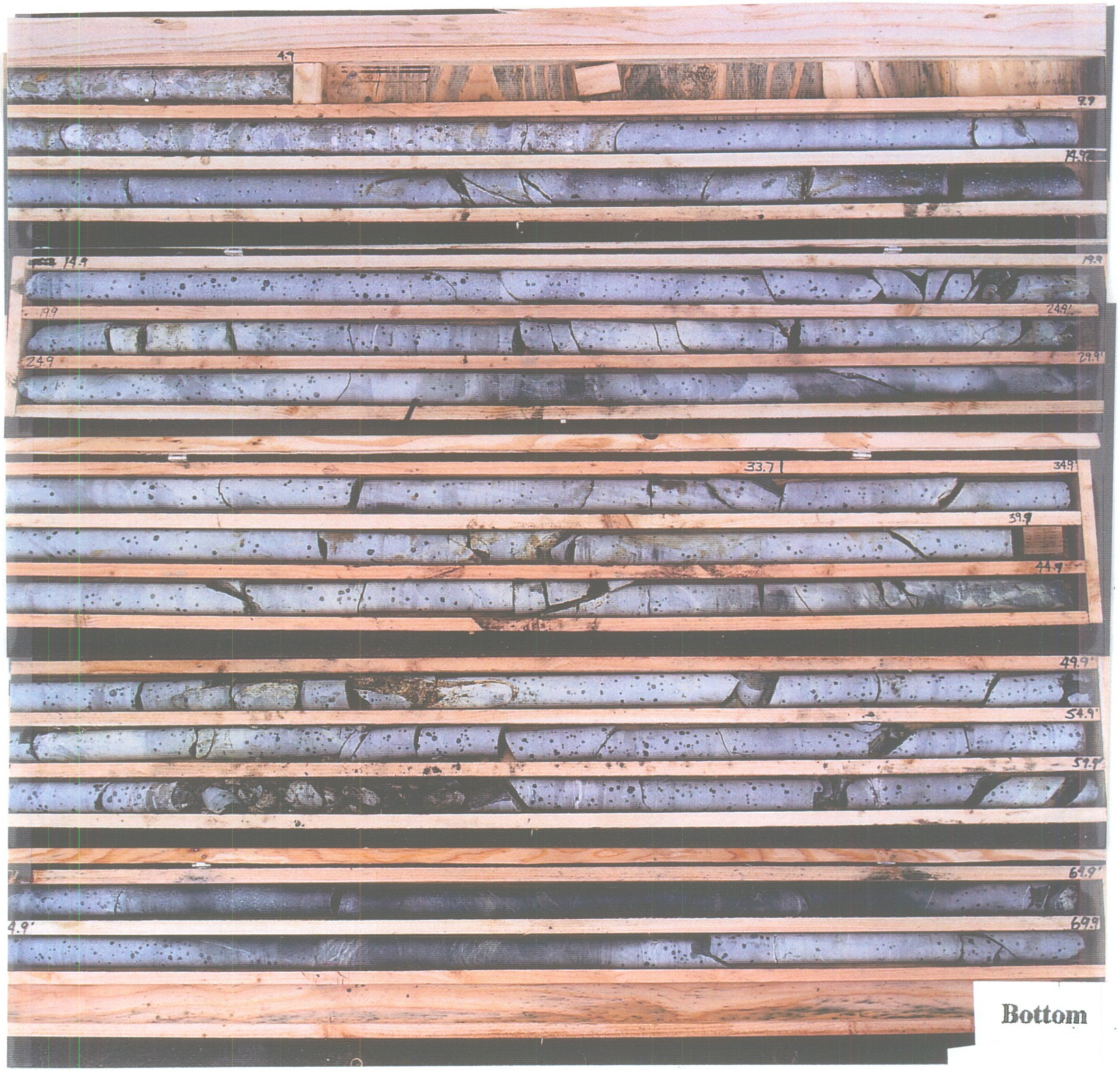
Top



Bottom

Core Hole 01

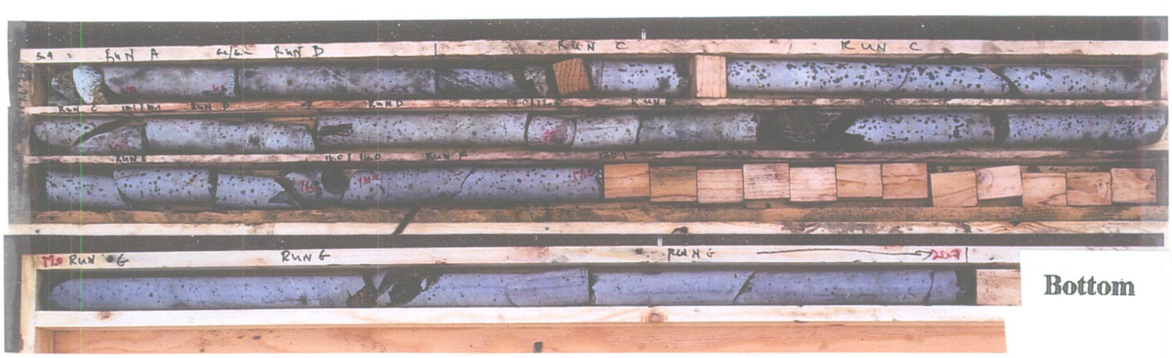
Top



Bottom

Core Hole 02

Top



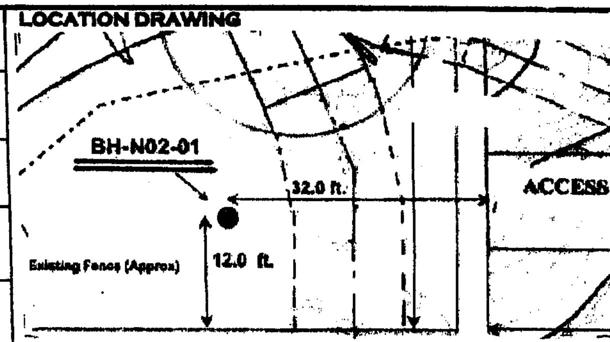
Bottom

Core Hole 03

PROJECT	DATE
Narrows 2 Bypass	12-23-'03

LOGGER	DRILLER/RIG
DHH.	Tabor Drilling Inc.
BORING	**ORIENTATION/DIP**
01	Vertical
ELEVATION, TOP OF HOLE	**BORING DEPTH**
348	69.7 Ft.
CASING	**DEPTH TO FIRST WATER**
NA	NA.

LOCATION DRAWING

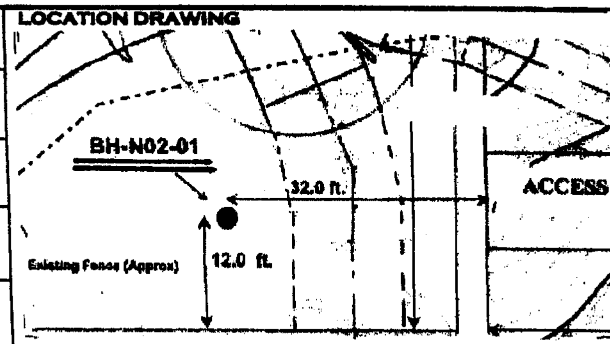


DEPTH	~~START/STOP~~ Run No.	RUNLENGTH/RECOVERY	RQD	DESCRIPTION: NAME, COLOR, WEATHERING, HARDNESS, BEDDING	FRACTURE ORIENT/TYPE	CORE DRAWING
~~10~~						
11		No Recovery.				
12						
13						
14	1	1.2/100%	55	Grey very hard, very fine-grained amphibolite meta-dike rock. Weathered only on fracture surfaces, with oxidized pyrite on fractures at top of core section. All fractures tight, with some chlorite coating. No shearing or crushing. Rock contains some disseminated fresh pyrite	Pyrite in fract.	
15						
16						
17	2	5.0/100%	28			
18						
19						
~~20~~					Drilling Break	

PROJECT	DATE
Narrows 2 Bypass	12-23-'03

LOGGER	DRILLER/RIG
DHH.	Tabor Drilling Inc.
BORING	**ORIENTATION/DIP**
01	Vertical
ELEVATION, TOP OF HOLE	**BORING DEPTH**
348	69.7 Ft.
CASING	**DEPTH TO FIRST WATER**
NA	NA.

LOCATION DRAWING

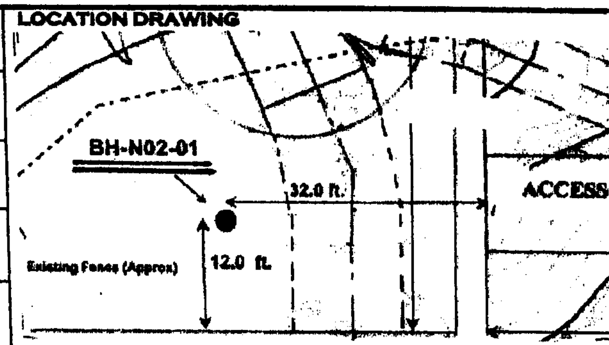


DEPTH	~~START/STOP~~ Run No.	RUNLENGTH/RECOVERY	RQD	DESCRIPTION: NAME, COLOR, WEATHERING, HARDNESS, BEDDING	FRACTURE ORIENT/TYPE	CORE DRAWING
~~20~~				Light grey hard fresh rock, becoming "speckled" with 2-3 mm feldspar (?) porphyoblasts.		
21						
22	3.	5.0/100%	78			
23						
24						
25						
26						
27	4.	5.0/100%	27			
28				Some weathering and alteration, poss. decomposed pyrite		
29						
~~30~~						

PROJECT	DATE
Narrows 2 Bypass	12-23-'03

LOGGER	DRILLER/RIG
DHH.	Tabor Drilling Inc.
BORING	**ORIENTATION/DIP**
01	Vertical
ELEVATION, TOP OF HOLE	**BORING DEPTH**
348	69.7 Ft.
CASING	**DEPTH TO FIRST WATER**
NA	NA.

LOCATION DRAWING

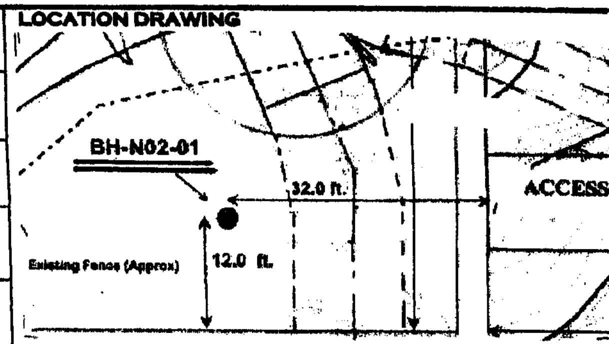


DEPTH	START/STOP Run No.	RUNLENGTH/ RECOVERY	RQD	DESCRIPTION: NAME, COLOR, WEATHERING, HARDNESS, BEDDING	FRACTURE ORIENT/TYPE	CORE DRAWING
30				"Speckled" light grey v. hard fresh amphibolite, as above.		
31						
32	5	5.0/100%	38			
33						
34						
35						
36						
37	6	5.0/100%	82			
38						
39						
40						

PROJECT	DATE
Narrows 2 Bypass	12-23-'03

LOGGER	DRILLER/RIG
DHH.	Tabor Drilling Inc.
BORING	**ORIENTATION/DIP**
01	Vertical
ELEVATION, TOP OF HOLE	**BORING DEPTH**
348	69.7 Ft.
CASING	**DEPTH TO FIRST WATER**
NA	NA.

LOCATION DRAWING

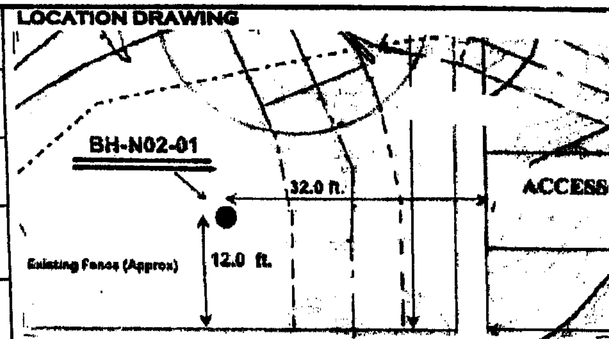


DEPTH	~~START/STOP~~ Run No.	RUNLENGTH/RECOVERY	RQD	DESCRIPTION: NAME, COLOR, WEATHERING, HARDNESS, BEDDING	FRACTURE ORIENT/TYPE	CORE DRAWING
40						
				Shattered zone, some weathering alteration.		
41						
42						
	7	5.0/100%	48			
43						
44				Closely fractured zone, 44.0-46.2		
45				45.2, Irregular 2-10 mm white veinlets, prob. calcite.		
46						
47	8	5.0/100%	41			
48						
49				Dark grey very fine-grained amphibolite, Light greenish grey veining -		
50						

PROJECT	DATE
Narrows 2 Bypass	12-23-'03

LOGGER	DRILLER/RIG
DHH.	Tabor Drilling Inc.
BORING	**ORIENTATION/DIP**
01	Vertical
ELEVATION, TOP OF HOLE	**BORING DEPTH**
348	69.7 Ft.
CASING	**DEPTH TO FIRST WATER**
NA	NA.

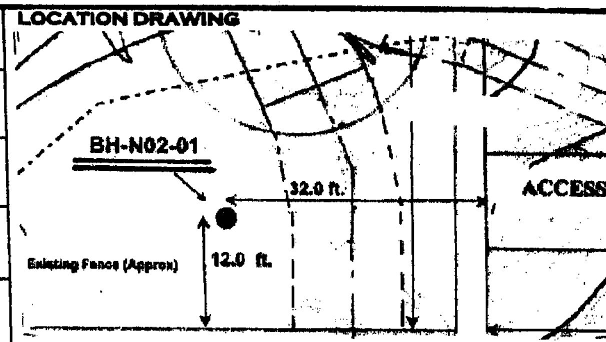
LOCATION DRAWING



DEPTH	~~START/STOP~~ Run No.	RUNLENGTH/RECOVERY	RQD	DESCRIPTION: NAME, COLOR, WEATHERING, HARDNESS, BEDDING	FRACTURE ORIENT/TYPE	CORE DRAWING
~~50~~					Clean rough break surface	
51					Break along light grn. grey Veining	
52				Light greenish grey Veining, not broken		
	9	5.0/100%	74			
53						
54						
55						
56						
57	10	5.0/100%	81			
58					Clean break along Calcite Veinlet	
59						
~~60~~						

PROJECT	DATE	LOCATION DRAWING
Narrows 2 Bypass	12-23-'03	

LOGGER	DRILLER/RIG
DHH.	Tabor Drilling Inc.
BORING	**ORIENTATION/DIP**
01	Vertical
ELEVATION, TOP OF HOLE	**BORING DEPTH**
348	69.7 Ft.
CASING	**DEPTH TO FIRST WATER**
NA	NA.

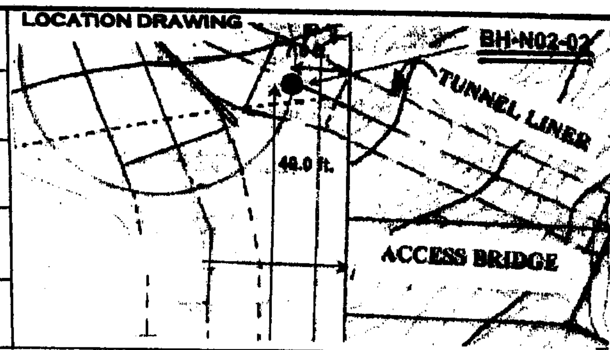


DEPTH	~~START/STOP~~ Run No.	RUNLENGTH/ RECOVERY	RQD	DESCRIPTION: NAME, COLOR, WEATHERING, HARDNESS, BEDDING	FRACTURE ORIENT/TYPE	CORE DRAWING
60						
61						
62	11	5.0/100%	72			
63						
64						
65						
66						
67	12	5.0/100%	77			
68						
69				Bottom of Hole.		
70						

PROJECT: Narrows 2 Bypass

DATE: 12-23-03.

LOCATION DRAWING



LOGGER: DHH

DRILLER/RIG: Tabor Drilling Inc.

BORING: 02.

ORIENTATION/DIP: Vertical

ELEVATION, TOP OF HOLE: 348

BORING DEPTH: 69.9 Ft.

CASING: NA

DEPTH TO FIRST WATER: NA

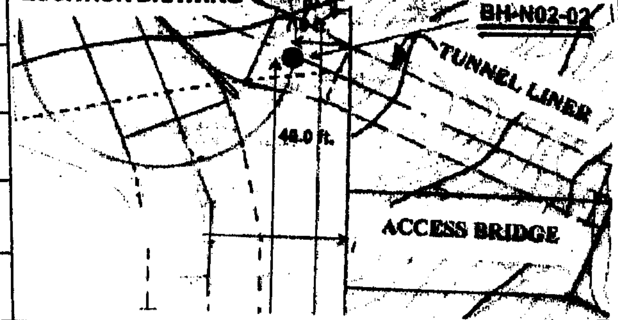
DEPTH	~~START/STOP~~ Run No.	RUNLENGTH/ RECOVERY	RQD	DESCRIPTION: NAME, COLOR, WEATHERING, HARDNESS, BEDDING	FRACTURE ORIENT/TYPE	CORE DRAWING
0–5		No Recovery				
5–7.9		Concrete				
7.9				Top of Rock.		
8–10	1	2.1/100%	71	Light grey, very fine grained, very hard, fresh amphibolite with 1-3 mm feldspar porphyroblasts giving rock a "speckled" aspect.		

Depth scale: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

PROJECT	DATE
Narrows 2 Bypass	12-23-03.

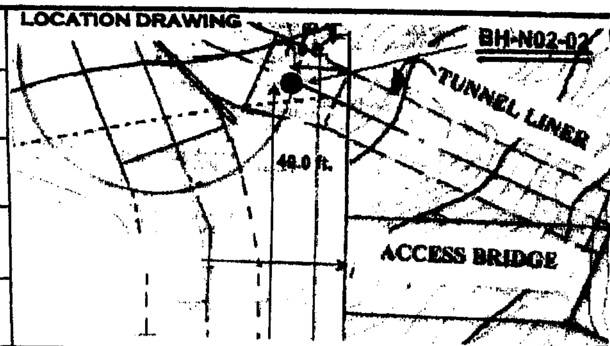
LOGGER	DRILLER/RIG
DHH	Tabor Drilling Inc.
BORING	**ORIENTATION/DIP**
02.	Vertical
ELEVATION, TOP OF HOLE	**BORING DEPTH**
348	69.9 Ft.
CASING	**DEPTH TO FIRST WATER**
NA	NA

LOCATION DRAWING



DEPTH	START/STOP Run No.	RUNLENGTH/RECOVERY	RQD	DESCRIPTION: NAME, COLOR, WEATHERING, HARDNESS, BEDDING	FRACTURE ORIENT/TYPE	CORE DRAWING
10						
11						
12						
13	2	5.0/100%	80			
14					Break along calcite veinlet	
15						
16						
17	3	5.0/100%	62			
18						
19					Closely fractured zone, sl. weathered.	
20						

PROJECT	DATE	LOCATION DRAWING
Narrows 2 Bypass	12-23-03.	



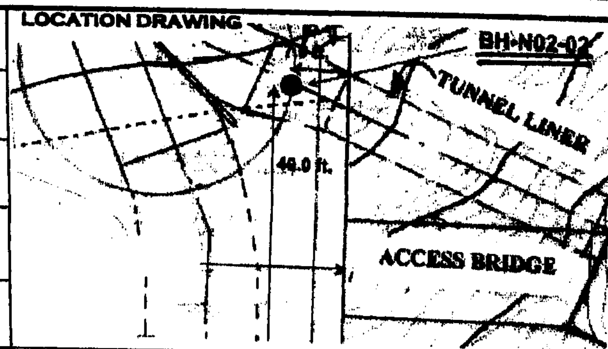
LOGGER	DRILLER/RIG
DHH	Tabor Drilling Inc.
BORING	**ORIENTATION/DIP**
02.	Vertical
ELEVATION, TOP OF HOLE	**BORING DEPTH**
348	69.9 Ft.
CASING	**DEPTH TO FIRST WATER**
NA	NA

DEPTH	START/STOP Run No.	RUNLENGTH/ RECOVERY	RQD	DESCRIPTION: NAME, COLOR, WEATHERING, HARDNESS, BEDDING	FRACTURE ORIENT/TYPE	CORE DRAWING
~~20~~						
21						
22						
	4	5.0/100%	68			
23						
24						
25						
26						
27						
	5	5.0/100%	78			
28						
29						
~~30~~						

PROJECT	DATE
Narrows 2 Bypass	12-23-03.

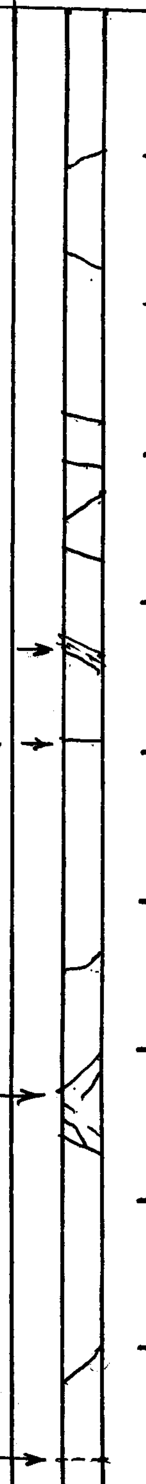
LOGGER	DRILLER/RIG
DHH	Tabor Drilling Inc.
BORING	**ORIENTATION/DIP**
02.	Vertical
ELEVATION, TOP OF HOLE	**BORING DEPTH**
348	69.9 Ft.
CASING	**DEPTH TO FIRST WATER**
NA	NA

LOCATION DRAWING



DEPTH	START/STOP Run No.	RUNLENGTH/ RECOVERY	RQD	DESCRIPTION: NAME, COLOR, WEATHERING, HARDNESS, BEDDING	FRACTURE ORIENT/TYPE
~~30~~					
31					
32					
	6.	5.0/100%	72		
33					
34					Broken calcite-lined joint.
35					Drilling break.
36					
37	7.	5.0/100%	70	Pyrite alteration - oxidized zone	
38					
39					
~~40~~					Drilling break.

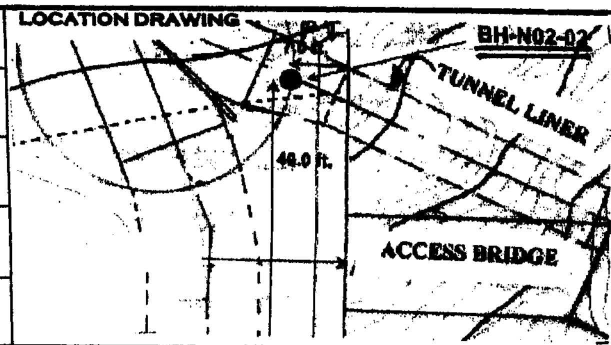
CORE DRAWING



PROJECT	DATE
Narrows 2 Bypass	12-23-03.

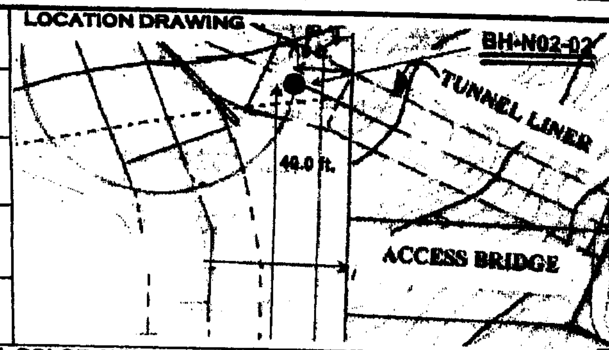
LOGGER	DRILLER/RIG
DHH	Tabor Drilling Inc.
BORING	**ORIENTATION/DIP**
02.	Vertical
ELEVATION, TOP OF HOLE	**BORING DEPTH**
348	69.9 Ft.
CASING	**DEPTH TO FIRST WATER**
NA	NA

LOCATION DRAWING



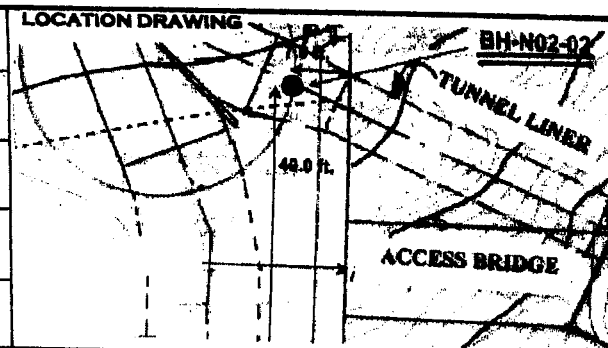
DEPTH	~~START/STOP~~ Run No.	RUNLENGTH/ RECOVERY	RQD	DESCRIPTION: NAME, COLOR, WEATHERING, HARDNESS, BEDDING	FRACTURE ORIENT/TYPE	CORE DRAWING
40						
41						
42	8	5.0/100%	57	Break on calcite and oxide lined fracture		
43						
44						
45						
46				Approximately vertical oxide surfaced fracture.		
47	9	5.0/100%	65			
48						
49					Drilling break.	
50						

PROJECT		DATE	LOCATION DRAWING
Narrows 2 Bypass		12-23-03.	
LOGGER	DRILLER/RIG		
DHH	Tabor Drilling Inc.		
BORING	ORIENTATION/DIP		
02.	Vertical		
ELEVATION, TOP OF HOLE	BORING DEPTH		
348	69.9 Ft.		
CASING	DEPTH TO FIRST WATER		
NA	NA		



DEPTH	~~START/STOP~~ Run No.	RUNLENGTH/RECOVERY	RQD	DESCRIPTION: NAME, COLOR, WEATHERING, HARDNESS, BEDDING	FRACTURE ORIENT/TYPE	CORE DRAWING
50						
51						
52						
53	10	5.0/100%				
54						
55						
56				Broken zone, fragments to 0.15' size		
57	11	5.0/100%		Vein calcite		
58						
59						
60						

PROJECT	DATE	LOCATION DRAWING
Narrows 2 Bypass	12-23-03.	

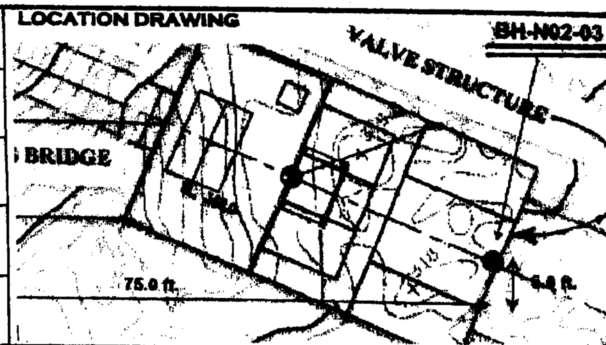


LOGGER	DRILLER/RIG
DHH	Tabor Drilling Inc.
BORING	**ORIENTATION/DIP**
02.	Vertical
ELEVATION, TOP OF HOLE	**BORING DEPTH**
348	69.9 Ft.
CASING	**DEPTH TO FIRST WATER**
NA	NA

DEPTH	~~START/STOP~~ Run No.	RUNLENGTH/RECOVERY	RQD	DESCRIPTION: NAME, COLOR, WEATHERING, HARDNESS, BEDDING	FRACTURE ORIENT/TYPE	CORE DRAWING
60						
61						
62				Zone of pervasive fine veining (epidote?)		
63	12	5.0/100%	75			
64						
65						
66						
67	13	5.0/100%	80			
68						
69						
70				Bottom of hole.	Drilling break	

PROJECT Narrows 2 Bypass.	**DATE** 12-23-'03.
LOGGER D.HH	**DRILLER/RIG** Tabor Drilling Inc.
BORING 03	**ORIENTATION/DIP** Vertical
ELEVATION, TOP OF HOLE 310 Ft.	**BORING DEPTH** 20.'
CASING NA	**DEPTH TO FIRST WATER** NA

LOCATION DRAWING

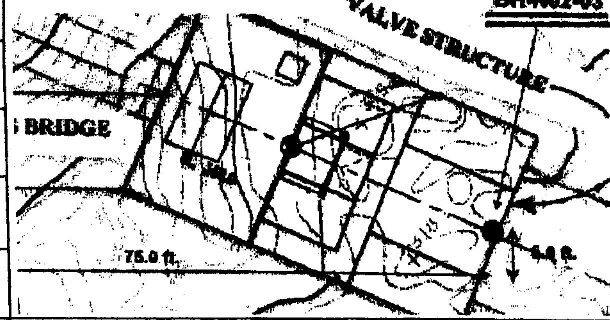


DEPTH	START/STOP	RUNLENGTH/RECOVERY	RQD	DESCRIPTION: NAME, COLOR, WEATHERING, HARDNESS, BEDDING	FRACTURE ORIENT/TYPE	CORE DRAWING
0						
1						
2						
3						
4						
5		5.4		Top of core,		
6	A	0.8/100%	62	(Probable top of rock under boulder rubble)		
		6.2		Light grey, very fine-grained, very hard, fresh amphibolite.		
	B	0.7/100%	100			
7		6.9				
8	C	3.2/100%	62			
9						
10		10.0				

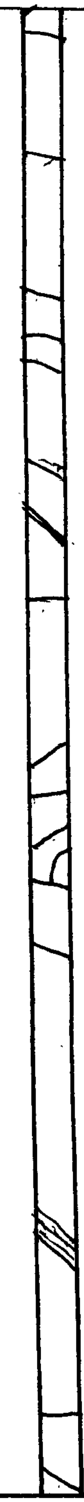
PROJECT	DATE
Narrows 2 Bypass.	12-23-'03.

LOGGER	DRILLER/RIG
DHH	Tabor Drilling Inc.
BORING	**ORIENTATION/DIP**
03	Vertical
ELEVATION, TOP OF HOLE	**BORING DEPTH**
310 ft.	20.'
CASING	**DEPTH TO FIRST WATER**
NA	NA.

LOCATION DRAWING



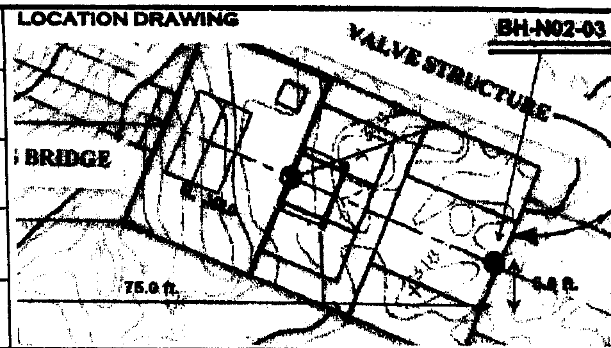
DEPTH	START/STOP	RUNLENGTH/RECOVERY	RQD	DESCRIPTION: NAME, COLOR, WEATHERING, HARDNESS, BEDDING	FRACTURE ORIENT/TYPE	CORE DRAWING
10		10.'				
11	D	1.9'/100%	84			
12		12.0				
13						
14	E	4.0/100%	59			
15						
16		16.0				
	F	1.0/100%	90			
17		17.0				
18	G	4.0/100%	95			
19						
20						



PROJECT	DATE
Narrows 2 Bypass.	12-23-'03.

LOGGER	DRILLER/RIG
DHH	Tabor Drilling Inc.
BORING	**ORIENTATION/DIP**
03	Vertical
ELEVATION, TOP OF HOLE	**BORING DEPTH**
310 Ft.	20.'
CASING	**DEPTH TO FIRST WATER**
NA	NA.

LOCATION DRAWING



DEPTH	START/STOP	RUNLENGTH/RECOVERY	RQD	DESCRIPTION: NAME, COLOR, WEATHERING, HARDNESS, BEDDING	FRACTURE ORIENT/TYPE	CORE DRAWING
~~20~~						
	G (Cont'd)					
21				Bottom of hole.	Drilling break	
22						